Thesis/
Reports
von
Ahlefeldt,
J.

BIOPHYSICAL AND HISTORICAL ASPECTS OF THE SPECIES AND ECOSYSTEMS OF THE MEDICINE BOW NATIONAL FOREST

BRIEFING NOTES ON

BIOPHYSICAL AND HISTORICAL ASPECTS OF SPECIES AND ECOSYSTEMS OF THE MEDICINE BOW NATIONAL FOREST

Citation: von Ahlefeldt, J.P. and C. Speas. 1996. **Biophysical and Historical Aspects of Species and Ecosystems of the Medicine Bow National Forest**. Specialist Report. Medicine Bow National Forest. Laramie, WY.

- Note that this is a specialist report, not a biodiversity assessment sanctioned by the Forest Plan Revision.

- The report has 10 chapters and 22 appendices.

- The last two appendices are a glossary and an index. The table of contents is detailed. There are lists of tables and figures for both the text chapters and the appendices in the Table of Contents.

- About 30% of the document is written text. The rest is tables, figures, photographs and references.

- Information is scaled using a watershed grid on maps and totals by different scales for tables. 5th or 6th level watersheds are the smallest units. There are 96 of these (biodiversity areas). These are aggregated into 16 biodiversity units. Data is presented in most tables by biodiversity area, summed to biodiversity units, summed again to mountain range totals and then summed to forest-wide.

- There will be discrepancies for tabular data among GIS data (used here), RIS data and District figures (especially planimetric figures). Use whichever you find to be the most accurate. The smaller the scale, often the more discrepancy. The tabular data was extracted from RIS by Carol Tolbert in winter of 1994-95. Our guideline was that about a 1% discrepancy was tolerable for large scales.

LIBRARY COPY
ROCKY MOUNTAIN RESEARCH STATION
FORT COLLINS CENTER

- Chapter Sequence:
  1. Introduction - Purpose, definitions, background
  2. Ecological theory - scales, ecosystem attributes
  3. Geography and climate
  4. History
  5. Photoessay on landscapes and other topics
  6. Terrestrial ecosystems (Coarse Filter)
  7. Aquatic ecosystems (Coarse Filter)
  8. Species and genetic level information (Fine Filter)
  9. Roadless areas, Wilderness, RNA's and Old Growth
  10. Concerns and Considerations

- Appendices
  1. Bibiography of studies done on the MEDBOW (over 900)
  2. Organization, names and metrics of watersheds
  3. Detailed climate information
  4. Documented plant species by mountain range (fine filter)
  5. Exotic plant species
  6. Working list of plant community types
  7. Lichens
  8. Fungi
  9. Animal species of mountain range (fine filter)
  10. Detailed Neotropical migratory bird information
  11. Acreage measurements of cover types for watersheds
  12. Acreage measurements of disturbance for watersheds for forested ecosystems in Medicine Bow and Sierra Madre Ranges
  13. Detailed watershed descriptions for streams or subbasins of each Biodiversity Area (by Clay Speas)
  14. Watershed health and identification of watersheds of concern
  15. Detailed information on fire (1945-1992)
  16. Results of administrative study of succession in clearcuts
  17. Landscape mosaic theory
  18. Preliminary Subsection descriptions (See May, 1996 RO map)
  19. Chronologies of historical events
  20. Relationship of TECS species of Biodiversity Areas
  21. Glossary
  22. Index

- There are color maps depicting cover type, mistletoe infection, riparian cover types, stand age, stand structural stage, stand scorecard information and old growth information in chapters 6,7 and 9.

- There is no discussion or information about timber volumes or ASQ. There is information on ecological attributes of forested stands such as cover type, stand age, structural stage, old growth score and level of mistletoe infection.

- All color maps and most black and white maps are on GIS and can be redone at other scales, or a portion may be printed enlarged.

- This report should provide a comprehensive conceptual tool, and a data base which provides large-scale approximations. RIS data continually changes, so figures should be rerun for projects. Tabular data in the report should provide an approximation for initial analyses.

- Hopefully this report will provide a solid foundation of information which can be built on in the future. It will also hopefully suggest some new ways of analysis and foster more questions. It should provide a common platform for discussions of landscape-scale items with publics.

- References in the accompanying letters to specific pages refer to the May, 1995 version, not the May, 1996 revision. Specific items referenced in the letters may have been changed or deleted and likely page numbers have changed.

Judy von Ahlefeldt, Forest Ecologist
June, 1996

ABOUT BIOPHYSICAL AND HISTORICAL ASPECTS OF SPECIES AND ECOSYSTEMS OF THE MEDICINE BOW NATIONAL FOREST 5/96

Preparation of this report was initiated in 1993 at the request of former Forest Supervisor Gary Heath. The report was prepared after identification of biological diversity issues for the Purpose and Need document for Forest Plan Revision (1993). Compilation of this information was initially intended for the Analysis of Management step in Forest Plan Revision but because of the suspension of MBNF Forest Plan Revision and loss of personnel in 1994-95, it evolved into a reference document to fill a long-standing need to locate and compile biophysical and historical information applicable to biological diversity and ecological integrity on the MBNF.

This report is not intended to be a completed biological diversity assessment for Forest Plan Revision. In order to fully assess the status of biological diversity for planning purposes, it is necessary to have an ID Team context and additional information from other assessments such as roads, and consumptive and non-consumptive uses.

This is a specialist report, prepared with data current through the end of 1994 and the first few months of 1995. Biological data is constantly changing as time goes on. RIS data is corrected, and additions are made; information is added to plant and animal data bases, and regulations or laws regarding which species are considered threatened, endangered, sensitive or "rare" also changes. This should be kept in mind when using this report. Landscape scale data from the RIS data base (cover type, stand age, structural stage, old growth scores) are rather stable and change very slowly over time, responsive mainly to human-caused or natural disturbance events, and succession. Thus the broad temporal and spatial scale ecosystem patterns portrayed by maps and figures should be valid for an extended time period barring major disturbance events such as large fires or blowdowns. Acreage figures provided in tables change as RIS data is corrected, updated or as new information is gathered, so tabular data should be rechecked for specific projects and it will be necessary to update some of the analyses where precise figures are needed. The numerical information in this report is best used as close approximations, rather than as exact, hard numbers. It is expected that further analysis will be conducted during Forest Plan Revision or for projects. Data will be updated as needed for these analyses.

The Biological Diversity Units and Areas, based on 5th and 6th level watersheds, do not coincide in some cases with the Draft Geographic Areas developed in early 1996 as the MBNF Forest Plan Revision resumed. Nonetheless the information in this report should provide ecosystem overviews scaled by forest-wide, to mountain range, to watershed

groups within mountain range and finally to 5th or 6th level watersheds, as a basis for initial analyses.

This report does not carry the endorsement of the Planning Team or the Leadership Team. It has been peer-reviewed by four scientists and an Administrative Review Team, and many changes recommended by these committees were made for the May, 1996 edition. It is a working document prepared by a fisheries biologist and forest ecologist with collaboration and cooperation from Wyoming Game and Fish, Forest Service Research and University of Wyoming scientists. Comments, concerns and corrections should be sent to:

Dr. Judy von Ahlefeldt, Forest Ecologist
Medicine Bow National Forest
2468 Jackson Street
Laramie, WY 82070

BIOPHYSICAL AND HISTORICAL ASPECTS OF SPECIES AND ECOSYSTEMS OF THE MEDICINE BOW NATIONAL FOREST

Prepared by:

Dr. Judy von Ahlefeldt,
Forest Ecologist

Clay Speas,
Fisheries Biologist

Medicine Bow National Forest
Laramie, Wyoming

May, 1995
Revised May, 1996

BIOPHYSICAL AND HISTORICAL ASPECTS OF SPECIES AND ECOSYSTEMS OF THE MEDICINE BOW NATIONAL FOREST

LIBRARY COPY
ROCKY MOUNTAIN RESEARCH STATION
FORT COLLINS CENTER

Prepared by:

Dr. Judy von Ahlefeldt,
Forest Ecologist

Clay Speas,
Fisheries Biologist

Medicine Bow National Forest
Laramie, Wyoming

May, 1995
Revised May, 1996

TABLE OF CONTENTS

SUMMARY i

GUIDE TO USING THIS REPORT v

ORGANIZATION OF THE REPORT vi

PREFACE xi

PRODUCTION CREDITS xii

1 INTRODUCTION **1- 1**
PURPOSE 1- 1
DEFINITIONS OF BIOLOGICAL DIVERSITY 1- 1
BIOLOGICAL DIVERSITY AND ECOLOGICAL INTEGRITY 1- 1
BIOLOGICAL DIVERSITY AND LIFE 1- 3
BIOLOGICAL DIVERSITY ISSUES 1- 4
NEED FOR THE REPORT 1- 5
OTHER REPORTS ON BIOLOGICAL DIVERSITY 1- 5
JUSTIFICATION FOR BIOLOGICAL DIVERSITY CONCERNS 1- 6
Law 1- 6
Policy 1- 9
National Policy 1- 9
Regional Policy 1-15
Forest Policy 1-16
Other Policy Discussions 1-16
Precedents 1-16
BIOLOGICAL DIVERSITY AND ECOSYSTEM MANAGEMENT 1-17
BIOLOGICAL DIVERSITY, CONSERVATION BIOLOGY AND THE SCIENTIFIC COMMUNITY 1-19
CONSERVATION OF BIOLOGICAL DIVERSITY AND ECOLOGICAL INTEGRITY 1-20
ADDITIONAL ANALYSES NEEDED 1-21
LITERATURE CITED 1-22

2 BIOLOGICAL DIVERSITY AND ECOSYSTEM SCALES - COMPOSITION, STRUCTURE, FUNCTIONS AND PROCESSES **2- 1**
FOREST SERVICE DIRECTION 2- 1
ECOLOGICAL THEORY AND BIODIVERSITY 2- 4
ECOSYSTEM COMPOSITION AND STRUCTURE 2- 6
ECOSYSTEM PROCESSES AND FUNCTIONS 2- 6
LITERATURE CITED 2- 8

3 THE GEOGRAPHIC AND CLIMATIC SETTING OF THE MEDICINE BOW NATIONAL FOREST 3- 1
GEOGRAPHY 3- 1
Mountain Ranges 3- 1
Land Classification 3- 2
GEOLOGY AND GEOMORPHOLOGY 3- 3
Mountain Ranges 3- 3
Earthquakes 3- 7
CLIMATE 3- 8
Climate Patterns 3- 8
Climate Effects on Plants 3-12
Climate Change 3-12
LITERATURE CITED 3-14

4 HISTORICAL ECOLOGY 4- 1
INTRODUCTION 4- 1
ROCKY MOUNTAIN PALEOCLIMATES AND PALEOECOLOGY 4- 2
Diversity of Vegetation over Geologic Time 4- 2
Post-Pleistocene Changes 4- 3
Climate Reconstructions 4- 6
THE PRE-1800 HISTORICAL PERIOD 4- 8
THE 1800-1849 HISTORICAL PERIOD 4- 9
Early Accounts 4-10
THE 1850-1902 HISTORICAL PERIOD 4-14
Terrestrial Ecosystems 4-14
Forests 4-14
Grasslands and Shrublands 4-17
Wildlife 4-18
Aquatic and Riparian Ecosystems 4-18
Stream Channels and Tie Driving 4-18
Hydraulic Mining and Dredging 4-22
Water Quality 4-23
Water Diversions 4-23
Beaver Populations and Riparian Areas 4-24
Fish Introductions 4-24
THE NATIONAL FOREST ADMINSTRATION PERIOD (1902-1995) 4-27
1902-1949 4-27
Terrestrial Ecosystems 4-27
Forests 4-27
Grasslands and Shrublands 4-33

Wildlife 4-34
Aquatic and Riparian Ecosystems 4-36
Beaver Management 4-36
Fish Introductions 4-36
1950-1995 4-37
Terrestrial Ecosystems 4-38
Forests 4-38
Wildlife 4-38
Aquatic and Riparian Ecosystems 4-39
Tie-driven Streams 4-39
Beavers and Riparian Areas 4-39
Water Projects and Sediment Spills 4-41
Fish Introductions 4-42
Timber Harvest 4-42
Roads 4-43
Recreation 4-43
LITERATURE CITED 4-44

5 PHOTOESSAY - A WALK THROUGH THE MEDICINE BOW NATIONAL FOREST 5- 1
ECOSYSTEM PHOTOGRAPHS 5- 3
ECOSYSTEM NARRATIVE 5-19
HISTORICAL AND AQUATIC ECOSYSTEM PHOTOGRAPHS 5-36
AERIAL PHOTOGRAPHS 5-45
MYCORRHIZAL PHOTOGRAPHS 5-54

6 TERRESTRIAL ECOSYSTEMS 6- 1
INTRODUCTION 6- 1
LANDSCAPE ORGANIZATION 6- 1
Biological diversity units and areas 6- 1
LANDSCAPE DIVERSITY 6- 2
Community Mosaic Diagrams 6- 2
Vegetation Classification 6- 3
MAJOR TERRESTRIAL ECOSYSTEMS 6- 3
Alpine ecosystems 6- 3
Upper Timberline 6- 4
Coniferous forests and woodlands 6- 7
Engelmann Spruce and Subalpine Fir Forests 6- 9
Diseases and insect infestations 6-10

Lodgepole Pine Forests 6-10
Diseases and insect infestations 6-12
- Comandra blister rust 6-12
- Dwarf mistletoe 6-12
- Mountain pine beetle 6-17
- Other diseases and disturbances 6-19
Ponderosa Pine Forests 6-19
Diseases and insect infestations 6-20
- Dwarf mistletoe 6-20
- Mountain pine beetle 6-20
- Other diseases 6-22
Limber Pine Forests 6-22
Douglas Fir Forests 6-22
Diseases 6-22
Rocky Mountain Juniper Woodlands 6-22
FOREST COMMUNITY TYPE CLASSIFICATION 6-23
FIRE IN CONIFEROUS FORESTS 6-23
Fire studies 6-23
Fire models 6-24
Presettlement fires 6-28
The historical forest 6-29
Fire in coniferous forest of the MBNF 6-30
Lodgepole Pine and Spruce-fir Forests 6-32
Ponderosa Pine Forests 6-33
The "range of natural variablity" of fire 6-33
Fire history since 1945 6-33
FOREST STRUCTURE AND SUCCESSION 6-35
Spruce-fir forests 6-35
Lodgepole pine forests 6-38
Ponderosa pine forests 6-39
FOREST PROCESSES AND FUNCTIONS 6-39
Forest hydrology 6-39
Nutrient cycling and other processes 6-42
DISTURBANCES OTHER THAN FIRE 6-43
Blowdown 6-44
Timber harvest 6-44
Clearcutting and partial cutting 6-45
History of timber harvst methods 6-45
Regeneration 6-49
TIMBER HARVEST AND BIOLOGICAL DIVERSITY 6-50
Wildlife habitat 6-51

Stand age and stand structure 6-53
Age fragmentation of forested landscapes 6-55
Landscape measurements 6-58
Pattern Analysis 6-58
Statistical procedure 6-60
Succession in clearcuts 6-66
Lichen biological diversity 6-68
Forest age continuity 6-70
ASPEN FORESTS 6-70
SHRUBLANDS AND GRASSLANDS 6-71
LITERATURE CITED 6-74

7 AQUATIC AND RIPARIAN ECOSYSTEMS 7- 1
INTRODUCTION 7- 1
CHARACTERISTICS OF AQUATIC ECOSYSTEMS 7- 4
Disturbance processes 7- 4
Watersheds of concern 7- 7
Watershed delineation 7-12
Watershed profiles 7-13
Types of aquatic ecosystems 7-20
High mountain lakes 7-20
Moraine ponds 7-21
Reservoirs 7-22
Streams 7-23
Aquatic communities 7-24
High mountain lakes 7-24
Moraine ponds 7-25
Streams 7-25
Fish biological diversity 7-32
RIPARIAN ECOSYSTEMS 7-36
Riparian area delineation 7-36
Riparian area vegetation 7-37
Disturbance in riparian areas 7-39
Concerns in riparian areas 7-47
LITERATURE CITED 7-49

8 BIOLOGICAL DIVERSITY OF SPECIES AND GENES 8- 1
INTRODUCTION 8- 1
INVERTEBRATE SPECIES DIVERSITY IN REPRESENTATIVE ECOSYSTEMS 8- 2
THREATENED OR ENDANGERED SPECIES, (FORMER) CANDIDATE SPECIES, AND REGION 2 SENSITIVE SPECIES 8- 8
Flora 8- 8
Fauna 8- 8
Tables of 8- 9
TECS species abstracts 8-17
Order of species abstracts 8-18
Plants 8-19
Animals 8-22
Fish 8-22
Amphibians 8-33
Reptiles 8-37
Mammals 8-38
Birds 8-45
NEOTROPICAL MIGRATORY BIRDS 8-71
Integration of NTMB into Forest Service policy 8-72
Forest Service roles and responsbilities 8-73
National level 8-74
Regional level 8-74
Forest level 8-74
Research stations 8-74
Regional monitoring and conservation goals 8-74
Monitoring guidelines 8-75
NTMB Research on the MBNF 8-76
Habitats utilized by NTMB on the MBNF 8-76
Management activities 8-77
Timber harvest 8-77
Livestock grazing 8-77
Snag reduction and removal 8-83
Old growth retention 8-85
Recreation 8-85
Other activities 8-85
Effects of forest fragmentation 8-85
NTMB and management indicator species (MIS) 8-86
BIG GAME CONSIDERATIONS 8-87
Large herbivores 8-87
Large predators 8-92
LITERATURE CITED 8-95

9 WILDERNESS AREAS, ROADLESS AREAS RESEARCH NATURAL AREAS AND OLD GROWTH 9- 1
INTRODUCTION 9- 1
WILDERNESS AREAS 9- 2
ROADLESS AREAS 9- 3
RESEARCH NATURAL AREAS 9-10
OLD GROWTH 9-19
The old growth issue 9-19
National and Regional policy and actions 9-19
MBNF Forest Plan minimum requirements 9-20
MBNF old growth evaluation 9-21
Old growth landscape analysis 9-22
Enhancement of minimum old growth requirements 9-28
The old growth patch and linkage system 9-29
Summary 9-33
LITERATURE CITED 9-34

10 CONCERNS AND CONSIDERATIONS 10- 1
INTRODUCTION 10- 1
GENERAL CONCERNS AND CONSIDERATIONS 10- 1
CONCERNS AND CONSIDERATIONS BY ECOSYSTEM SCALE 10- 3
Terrestrial ecosystems 10- 3
Coarse filter 10- 3
Fine filter 10- 3
Aquatic and riparian ecosystems 10- 3
Coarse filter 10- 3
Fine filter 10- 3
CONCERNS AND CONSIDERATIONS BY TOPIC 10- 4
Old growth 10- 4
Aquatic and riparian ecosystems 10- 7
Species and genetic biological diversity 10- 7
CONCERNS AND CONSIDERATIONS BY LANDSCAPE AREA 10- 8
Sierra Madre and Medicine Bow Mountains 10- 8
Terrestrial ecosystems 10- 8
Aquatic and riparian ecosystems 10- 8
Sherman Mountains and Laramie Mountains 10- 8
Terrestrial ecosystems 10- 8
Aquatic and riparian ecosystems 10- 9
LITERATURE CITED 10-10

LIST OF TABLES

1.1 Definitions of biological diversity 1- 2

1.2 Synopsis of major legislation to conserve species and ecosystems 1- 8

2.1 Hierarchy for description of biological diversity 2- 2

3.1 Classification of the Medicine Bow National Forest - National Hierarchy of Ecological Units 3- 4

3.2 Landtype Associations Categories using a landform/elevation matrix 3- 4

3.3 Medicine Bow National Forest preliminary Subsections and Landtype Associations 3- 5

3.4 Earthquakes in Southeastern Wyoming 3- 8

3.5 El Nino and La Nina years 3-11

3.6 Extremes of annual precipitation, 1948-1993 3-11

4.1 Periods of cool and warm summer temperatures in Western North America since 1600 . . . . . 4- 6

4.2 Known tie-driven streams 4-20

4.3 Stocking of exotic fish into North Platte, South Platte and Little Snake River drainages 4-25

4.4 Overview of historical grazing outputs 4-35

6.1 Dwarf mistletoe status of watersheds 6-14

6.2 Outbreaks of mountain pine beetle 1895-1943 6-20

6.3 Mean fire return intervals for selected areas in the Western United States 6-27

6.4 Approximate year of origin and remnant patch size for fire history in a portion of the Encampment River watershed 6-31

LIST OF TABLES (continued)

6.5 Publications containing recommended timber harvest methods for lodgepole pine 1954-1988 6-47

6.6 Publications containing recommended timber harvest methods for spruce-fir 6-48

6.7 Disturbance acreage and forest age classes for lodgepole pine and spruce-fir forest 6-56

6.8 Watersheds (BDUs) with more than 15% of their area cumulatively clearcut since 1950 6-64

6.9 Seral stage and ecosystem condition matrix 6-73

7.1 Approximate ranges of recurrence intervals for major disturbance events 7- 5

7.2 Eighth level watersheds of concern 7- 8

7.3 Macroinvertebrate species list for the MBNF 7-27

7.4 Indigenous fish species 7-33

7.5 Introduced fish species 7-35

7.6 Net NFS acres and percent riparian area in each BDA 7-37

7.7 Categories of riparian vegetation 7-39

7.8 Examples of common riparian community types 7-40

7.9 Cover types of riparian areas by BDA 7-41

8.1 Synopsis of high elevation communities 8- 4

8.2 Federally threatened or endangered species of the MBNF 8- 9

8.3 USFWS (former) Candidate species known from the MBNF 8-10

8.4 USFS Region 2 sensitive species 8-11

LIST OF TABLES (continued)

8.5	Plant species of special concern (Wyoming Natural Diversity Database, 1994)	8-13
8.6	Animal species of special concern (Wyoming Natural Diversity Database	8-15
8.7	Species of concern to conservation groups	8-16
8.8	Colorado River cutthroat trout genetic purity characteristics for the Little Snake River Enclave, Wyoming	8-26
8.9	List of neotropical migratory birds of the MBNF	8-79
8.10	Habitat matrix for neotropical migratory birds of concern on the MBNF	8-82
8.11	Cavity-nesting neotropical migratory birds of the MBNF	8-84
8.12	Big game population estimates	8-88
8.13	Population and harvest data for game animals and birds	8-90
8.14	Black bear and mountain lion harvest, 1990-1994	8-94
9.1	Wilderness area acreages as per cent of mountain range	9- 2
9.2	Net acreages, and percentage of RARE II and wilderness areas	9- 5
9.3	Timber sales in roadless areas scheduled in the 1985 Forest Plan	9- 7
9.4	Existing, proposed and potential RNAs - location, acres and elevation categories	9-12
9.5	Existing, proposed and potential RNAs - by mountain range	9-13
9.6	Major vegetation categories represented by existing, potential and proposed RNAs	9-14
9.7	Major plant communities represented in existing, potential and proposed RNAs on the MBNF	9-15

LIST OF TABLES (concluded)

9.8 Acreages of interior old growth forest for various cover types with 0 and 60 meter edge effect zone 9-24

9.9 Reduction of interior forest area for selected watersheds when a 60 meter edge effect zone is applied 9-27

9.10 Attributes of the Old Growth Patch and Linkage System 9-32

LIST OF FIGURES

3.1	Forested mountain areas in Northern New Mexico, Colorado and Southern Wyoming	3-18
3.2	Vicinity Map - Medicine Bow National Forest	3-19
3.3	Relationship of the MBNF to preliminary Subections of the National Ecological Hierarchy	3-21
3.4a	Generalized geology map of Precambrian rocks of the Sierra Madre and Medicine Bow Mountains	3-32
3.4b	Generalized geology map of the Precambrian and Cretaceous rocks of the Laramie Mountains	3-33
3.5	Location and elevation of weather stations in the vicinity of the MBNF	3-24
3.6	Climatograms for mountain weather stations on or near the MBNF	3-25
4.1	A map of the southern Rocky Mountains - 1842	4-54
4.2	Fremont's map (1842) of the Sierra Madre, Medicine Bow and Laramie Mountains	4-55
4.3	Fremont's map of the Laramie Mountains (1942)	4-56
4.4	Watersheds with known tie-driven streams	4-57
6.1 a-c	Biodiversity Analysis Units and Biodiversity analysis areas	6-91
6.2 a-d	Cover type maps for the MBNF	6-95
6.3	Diversity of major terrestrial cover types of each mountain range of the MBNF	6-99
6.4	Community mosaic diagram for the Medicine Bow Mountains	6-100
6.5	Community mosaic diagram for a portion of the Savage Run Wilderness Area	6-101
6.6a a-j	Ranges of major forest types in North America	6-102

6.7	Forest diversity among the mountain ranges of the MBNF expressed as per cent tree cover	6-105
6.8 a-b	Spruce-fir cover type location for the Sierra Madre and Medicine Bow Mountains	6-106
6.9 a-b	Lodgepole pine cover type location for Sierra Madre and Medicine Bow Mountains	6-108
6.10 a-d	Distribution and infection levels of dwarf mistletoe in lodgepole pine	6-110
6.11	Generalized forest succession diagram for lodgepole pine in cool habitat types	6-114
6.12	Generalized fire cycle diagram for lodgepole pine	6-114
6.13	Concept diagram for spruce-fir forest development - Savage Run Wilderness	6-115
6.14	Cumulative acreages of stand origin (1692-1992) and fire evidence in the southern Sierra Madre Mountains	6-116
6.15	Relationship of tree age and DBH for ponderosa pines in the Ashenfelder Basin area, Laramie Mountains	6-117
6.16	Number of fires by size class compared to acres burned by size class since 1945	6-118
6.17	Fire occurrence and cause, by year, for each mountain range in the MBNF (1945-1992)	6-119

6.18 Diversity of types of age structure in spruce-fir forests resulting from differential recruitment 6-120

6.19 Continuum of possible patterns of tree reproduction and canopy recruitment for lodgepole pine/spruce forests 6-120

6.20 Diagram of major successional trends following light or severe forests fires in Rocky Mountain subalpine forests 6-121

6.21 State and transition model for forest succession in the Sierra Madre Mountains 6-122

6.22 Successional models for lodgepole pine forests (Region 1) 6-123

6.23 State and transition successional stages for an Arizona ponderosa pine-bunchgrass habitat type 6-124

6.24 Forest hydrology water budget for a lodgepole pine forest near Foxpark, WY 6-125

6.25 Aerial view of 5H-wide clear cut experiment to determine snow catchment in openings 6-126

6.26 a-c Three strip cut systems for lodgepole pine 6-126

6.27 Relative rankings of effects of silvicultural systems on resources of spruce-fir forests 6-128

6.28 Conditions favorable and unfavorable to the natural regeneration of Engelmann spruce 6-129

6.29 a-b Stand age map for the Medicine Bow and Sierra Madre Mountains 6-130

6.30 Acres of forest per age class category for the Sierra Madre and Medicine Bow Mountains 6-132

6.31 a-b Habitat structural stage maps for the Medicine Bow and Sierra Madre Mountains 6-133

6.32 a-b Vegetation disturbance maps for the Medicine Bow and Sierra Madre Mountains 6-135

6.33 Interior area of forest patches originating before 1850 6-137

6.34 Acres clear cut and partial cut by year, 1950-1994 Sierra Madre Mountains (a-h) Medicine Bow Mountains (a-k) 6-138

6.35 a-j Cumulative acres harvested, 1950-1994 6-142

6.36 Reference areas for landscape measurements for mean values of the "range of natural variability" 6-145

6.37 Cumulative areas harvested from 1960-1993 in the southeastern Sierra Madre Mountains 6-146

6.38 Graphs of cumulative number of patches, patch size, average amount of edge and total edge for the southeastern Sierra Madre Mountains 6-147

6.39 Aspen cover type location map 6-148

7.1 a-b Watersheds of concern - Sierra Madre and Medicine Bow Mountains 7-53

7.2 a-d Riparian area cover types 7-55

8.1 Colorado River cutthroat trout distribution map 8-108

8.2 a-b Boreal toad distribution map 8-109

8.3 Wood frog distribution map 8-111

8.4 a-e Mule deer seasonal ranges 8-112

8.5 a-e Elk seasonal ranges 8-117

8.6 a-d Antelope seasonal ranges 8-122

8.7 a-d Bighorn sheep seasonal ranges 8-125

9.1 Major cover types of wilderness areas 9-36

9.2	RARE II roadless areas (1976-1985).	9-37
9.3 a-c	Proposed and potential research natural areas	9-38
9.4 a-b	Interior (more than 5 ac patches) old growth forest with and without a 60 meter edge effect zone	9-41
9.5 a-b	Proposed Old Growth Patch and Linkage system illustrating Designated and Non-Designated areas	9-43
9.6 a-b	Stand age attributes of Old Growth Patch and Linkage System	9-45
9.7 a-b	Habitat structural stage attributes of Old Growth Patch and Linkage System	9-47
9.8 a-b	Old Growth Scorecard attributes of Old Growth Patch and Linkage System	9-49
9.9 a-b	Relationship of Old Growth Patch and Linkage System to timber suitability	9-51
9.10 a-b	Major cover types of the Old Growth Patch and Linkage System	9-53
9.11 a-b	Overall Old Growth Scorecard map	9-55

TABLE OF APPENDICES

AP1 - Bibliography of scientific studies pertaining to the MBNF

AP2 - Watersheds, biodiversity areas and units

AP3 - Climatic diversity of the MBNF

AP4 - Plant species biological diversity

AP5 - Exotic plant species

AP6 - Plant community diversity of the MBNF

AP7 - Lichen species biological diversity

AP8 - Fungal species biological diversity

AP9 - Animal species biological diversity

AP10 - Neotropical migratory birds

AP11 - Acreage measurements of cover types

AP12 - Acreage measurements of disturbance in forested ecosystems

AP13 - Watershed descriptions for each biodiversity area

AP14 - Watershed health - criteria and anlaysis methods for determining watersheds of concern

AP15 - Fire occurrence on the MBNF 1945-1993, and fire history

AP16 - Biological diversity of clearcuts created 1950 to 1992 - Medicine Bow Mountains

AP17 - Landscape mosaics - patches and networks

AP18 - Descriptions of ECOMAP preliminary Subsections

AP19 - Chronologies of historical events

AP20 - Occurrence of TECS species by Biodiversity Area

AP21 - Glossary of terms

INDEX

LIST OF APPENDIX TABLES

APPENDIX 2 TABLE	WATERSHEDS, BIODIVERSITY AREAS, BIODIVERSITY UNITS	PAGES
AP2.1	Biological Diversity Analysis Areas	AP2- 3
AP2.2	Watersheds and Mountain Ranges	AP2- 3
AP2.3	Acreages for Biodiversity Areas and Biodiversity Units	AP2- 4
AP2.4	5th and 6th level watersheds within Biodiversity Areas	AP2- 9
APPENDIX 3	**CLIMATIC DIVERSITY OF THE MBNF**	
AP3.1	Station elevations and years of record	AP3- 5
AP3.2	Annual total precipitation, estimated snowfall and mean annual temperature	AP3- 6
AP3.3	Monthly and annual precipitation	
AP3.4	Mean monthly and mean annual temperatures	AP3- 7
AP3.5	Elevation differences, distances, and temperature and precipitation lapse rates for portions of the MBNF	AP3- 8
APPENDIX 4	**PLANT SPECIES BIOLOGICAL DIVERSITY**	
AP4.1	Species totals by life form	AP4- 5
AP4.2	Species richness by life form for mountain ranges	AP4- 5
AP4.3	Plant species of the MBNF	AP4- 6
APPENDIX 5	**EXOTIC PLANT SPECIES ON THE MBNF**	
AP5.1	Exotic plant species found on the MBNF	AP5- 3
AP5.2	Exotic species which are also designated weeds	AP5- 5

APPENDIX 6 TABLE	PLANT COMMUNITY DIVERSITY OF THE MEDICINE BOW NATIONAL FOREST	PAGES
AP6.1	Working list of community types	AP6- 4
APPENDIX 7	**LICHEN SPECIES BIOLOGICAL DIVERSITY**	
AP7.1	Characteristics of lichens known from the MBNF	AP7-15
AP7.2	Lichens of the MBNF	AP7-17
AP7.3	Lichens by Ordination Group	AP7-18
APPENDIX 8	**FUNGAL SPECIES BIOLOGICAL DIVERSITY**	
AP8.1	List of 87 macrofungi collected at Foxpark study sites, 1988-1991	AP8- 4
APPENDIX 9	**ANIMAL SPECIES BIOLOGICAL DIVERSITY**	
AP9.1	Vertebrate animal species of the MBNF by vertebrate group and status	AP9- 3
AP9.2	Species historically present or for which there is insufficient evidence as to present occurrence	AP9- 3
AP9.3	Vertebrate animal species list for the MBNF	AP9- 4
APPENDIX 11	**ACREAGE MEASUREMENTS OF COVER TYPE**	
AP11.1	Acres of upland cover types, riparian cover type sum and total acres in each BDU and BDA	AP11- 3
AP11.2	Acres of each major tree species in each BDU and BDA	AP11- 9

APPENDIX 12 TABLE	ACREAGE MEASUREMENTS OF DISTURBANCE IN FORESTED ECOSYSTEMS	PAGES
AP12.1	Acreages of uncut forest in age categories, and acres of partial cuts, group shelterwood cuts, clearcuts, and fire/blowdown in each BDA	AP12- 3
AP12.2	Acreages of uncut lodgepole pine forest in age categories, and acres of partial cuts, group shelterwood cuts, clearcuts, and fire/blowdown in each BDU	AP12- 7
AP12.3	Acreages of uncut spruce-fir forest in age categories, and acres of partial cuts, group shelterwood cuts, clearcuts, and fire/blowdown in each BDU	AP12-18
AP12.4	Acres clearcut each year for each BDA	AP12-29
AP12.5	Acres partial cut each year for each BDA	AP12-31
APPENDIX 15	**FIRE OCCURRENCE ON THE MBNF 1945-1993, AND FIRE HISTORY**	
AP15.1	Number of fires, cause and acreage burned - MBNF 1945-1993	AP15-16
AP15.2	Number and per cent of fires by size class and cause	AP15-17
AP15.3	Number of fires by elevation classes	AP15-18
AP15.4	Fire occurrence standarized to fires/million acres	AP15-19
AP15.5	Number of fires, acres burned and fires/MM acres, and acres burned/MM acres by size class and cause	AP15-19
AP15.6	Summary by fire size class, number of fires and acreage burned	AP15-21

LIST OF APPENDIX TABLES (continued)

TABLE		PAGES
AP15.7	Class E fires	AP15-22
AP15.8	Class F fires	AP15-22
AP15.9	Number of fires and acres burned on the Roosevelt, Routt and Medicine Bow National Forests (1960-1973)	AP15-23
AP15.10	Number of fires and acres burned on the MBNF (1960-1973)	AP15-23
AP15.11	Number of fires by size class and cause for the Roosevelt, Routt, and Medicine Bow National Forests	AP15-24
AP15.12	Fire occurrence by size class for 1960-1973 on the MBNF	AP15-25
AP15.13	Fire occurrence by state (1960-1973)	AP15-26
AP15.14	Fire occurrence by state per million acres (MMac) protected (1960-1975)	AP15-26
AP15.15	Number of fires and area burned in Regions 1,2 and 3 (1960-1975)	AP15-26
AP15.16	Number of fires by size class (MBNF)	AP15-27
APPENDIX 16	**BIOLOGICAL DIVERSITY OF CLEARCUTS CREATED 1950-1992**	
AP16.1	Common landtypes used for clearcut study site selection in the Medicine Bow and Sierra Madre Mountains	AP16-16
AP16.2	Macrofungi genera from clearcut and uncut sites	AP16-16
AP16.3	Species list for ordination groups	AP16-17
AP16.4	Shrub presence in ordination groups	AP16-21
AP16.5	Major species in each ordination group	AP16-22

LIST OF APPENDIX TABLES (concluded)

APPENDIX 19	CHRONOLOGIES OF HISTORICAL EVENTS	PAGES
TABLE		
AP19-1	Historical Overview	AP19- 2
AP19.2	Medicine Bow National Forest Organizational Chronology	AP19- 3
AP19.3	Forest Fires noted in the Historical Records	AP19- 3
AP19.4	Medicine Bow National Forest chronology of events - 1838-1899	AP19- 4
AP19.5	Medicine Bow National Forest chronology of events 1900-1949	AP19- 7
AP19.6	Medicine Bow National Forest chronology of events 1950-1993	AP19-11
APPENDIX 20	**OCCURRENCE OF TECS SPECIES BY BIODIVERSITY AREA**	
AP20.1	Records of sightings of TES species, by Biodiversity Area, (1985-1994)	AP20- 1
AP20.2	Records of sightings of TES species, by Biodiversity Area, prior to 1985	AP20- 3
AP20.3	Records of sightings of TES species, by Biodiversity Area, no date	AP20- 5
AP20.4	TES Data summary by Biodiversity Area and time period	AP20- 7

LIST OF APPENDIX FIGURES

APPENDIX 2 FIGURES	**WATERSHEDS, BIODIVERSITY AREAS, BIODIVERSITY UNITS**	**PAGES**
AP2.1 a-d	Maps of Biodiversity Units and Biodiversity Areas .	AP2-21
APPENDIX 3	**CLIMATIC DIVERSITY OF THE MBNF**	
AP3.1	Climatic gradients of monthly precipitation and temperature across north central Colorado and southeastern Wyoming	AP3-10
AP3.2	Climatograms for 32 stations in the vicinity of the MBNF	AP3-11
AP3.3	Temperature lapse rates	AP3-15
AP3.4	Precipitation lapse rates	AP3-16
APPENDIX 11	**ACREAGE MEASUREMENTS OF COVER TYPES**	
AP11.1	Percent cover of major upland cover types within each mountain range	AP11-16
AP11.2	Percent cover of tree species for each BDA	AP11-19
APPENDIX 14	**WATERSHED HEALTH**	
AP14.1 a-b	Landslide areas	AP14-10
APPENDIX 15	**FIRE OCCURRENCE ON THE MBNF (1945-1993) AND FIRE HISTORY**	
AP15.1	Number of fires by elevation classes for each mountain range on the MBMF	AP15-28
AP15.2	Number of fires by elevation classes for subdivisions of mountain ranges	AP15-29
AP15.3	Number of man-caused fires compared to lightning-caused fires, by elevation classes for each mountain range	AP15-30

FIGURES		PAGES
AP15.4	Man-caused vs lightning-caused fires, by elevation class	AP15-31
AP15.5	Yearly pattern of man-caused and lightning-caused fires by mountain range	AP15-32
AP15.6	Number of fires, size and acres burned (1945-1993)	AP15-33
AP15.7	Comparision of number of fires, acres burned and cause	AP15-34

APPENDIX 16 BIOLOGICAL DIVERSITY OF CLEARCUTS CREATED 1950-1992

AP16.1	Distribution of stands for the clearcut succession study	AP16-26
AP16.2	Ordination groups based on understory vegetation	AP16-27
AP16.3	Mean value of conifer ectomycorrhizae tips	AP16-28
AP16.4	Mean value of percent infected *Vaccinium* tips	AP16-28
AP16.5	Density of seedlings, saplings, poles and mature trees, Groups 1 and 5	AP16-29
AP16.6	Density of seedlings, saplings, poles and mature trees, Groups 6 and 7	AP16-30
AP16.7	Density of seedlings, saplings, poles and mature trees, Groups 10 and 11	AP16-31
AP16.8	Arrangement of tree size and density by ordination group	AP16-32
AP16.9	Soil fertility in lodgepole pine stands	AP16-33
AP16.10	Soil fertility in spruce-fir and mixed conifer stands	AP16-34

LIST OF APPENDIX FIGURES (concluded)

FIGURES		PAGES
APPENDIX 17	**LAND MOSAICS - PATCHES AND NETWORKS**	
AP17.1	Types and characteristics of networks	AP17- 4
AP17.2	Types of patches	AP17- 5
AP17.3	Types of spatial patterns	AP17- 6

SUMMARY

The Medicine Bow National Forest (MBNF) is located at the northern end of the Northern Parks and Ranges Ecological Section (M331I). The Medicine Bow and Sierra Madre Mountains are peninsulas respectively continuous with the forests of Front Range and Park Range in Colorado. The Medicine Bow and Sierra Madre mountains are bounded by sharp transitions to grasslands or shrub-steppe of the Laramie Basin or Great Basin. The Pole Mountain administrative unit in the Sherman Mountains, and the Laramie Mountains, are both forested islands surrounded by grasslands, shrublands or low density woodlands of ponderosa pine or limber pine. The are bordered on the east by the Great Plains. Some limited areas around the edges of the Medicine Bow and Sierra Madre Ranges are in the Central Basin and Hills Ecological Section (342F).

Climate varies substantially from west to east and also because of elevation. The Sierra Madre Range is wetter and milder than the Medicine Bow Mountains, Sherman Mountains and most of the Laramie Mountains. Lower elevations have dry, cold climates while higer elevations have heavy winter snow. Annual precipitation to recharge soil moisture comes mainly as winter or spring snow. High elevations near the Continental Divide in the Sierra Madre, and around Medicine Bow Peak average about 50 inches of annual precipitation, mostly as winter snow.

Streams on the Sierra Madre Mountains flow into the Colorado River west of the Continental Divide. Most other streams on the MBNF are tributary to the North Platte River.

Primary forest types of the Medicine Bow and Sierra Madre Mountains are lodgepole pine, mixed conifer (lodgepole pine, Engelmann spruce and subalpine fir), Engelmann spruce-subalpine fir and Engelmann spruce. Limber pine occurs on severe sites, aspen occupies large areas in the western Sierra Madre Mountains in association with Gambel oak and other shrubs, but occurs in smaller patches, often in riparian settings elsewhere. Ponderosa pine is the dominant forest type in the southern Laramie Mountains and parts of the Sherman Mountains. Lodgepole pine and subalpine fir dominate Pole Mountain and the northern Laramie Mountains. Limber pine, Douglas fir, and Engelmann spruce are less common tree species.

The Laramie Mountains and Sherman Mountains have expanses of grassland and shrublands in broad valleys with Tertiary or Quaternary alluvial deposits. Species composition is similar to the Great Plains. Grasslands and shrublands in the Sierra Madre and Medicine Bow Mountains are mostly around the edges at lower elevations with bunchgrasses and sagebrush. The Battle Creek Valley in the Sierra Madre is an exceptional grassland-shrubland ecosystem on the MBNF.

Large canyons are found throughout the MBNF (Deer Creek Canyon, LaBonte Canyon, Ashenfelder Canyon, Murphy Canyon, the Laramie River Canyon, Horseshoe Canyon, Rock Creek Canyon, the Platte River Canyon, the Encampment River Canyon, North Fork Little Snake River, French Creek Canyon). These canyons offer sheltered sites for uncommon or endemic plant and animal species.

High ignition rates (ignitions per million acres) from lightning characterize the Laramie and Sherman Mountains. Actual numbers of fires and acres burned are fairly low because of the small area, topographic and vegetation factors and effective fire suppression. Fire ignition rates from lightning are low in both the Medicine Bow and Sierra Madre Mountains. In the last 50 years, human-caused and lighting caused fires are about equal for the Sierra Madre Sherman Mountains; lightning-caused fires outnumber man-caused fires about 3:1 in the Laramie Mountains but human-caused fires outnumber lightning caused fires 2:1 in the Medicine Bow Mountains. About 72 per cent of the acreage affected by fire in the the past 50 years has been due to seventeen fires. This is approximately 20,500 acres out of a total of 29,000 acres burned from all fires (1465 fires).

Pre-1800 fires at low elevation ponderosa pine ecosystems or woodlands with limber pine in the Laramie and Sherman Mountains were likely predominantly surface fires which thinned new tree growth and rejunvenated fire-adapted shrubs and grasses. Patch size is unknown and fire scar studies have not been done. Pre-1800 fires in the Sierra Madre and Medicine Bow Mountains at high elevations appear to be extremely infrequent (300-500 years or more). These would likely be stand-destroying fires but little actual data exists for the MBNF. Lower elevation lodgepole pine forests probably burned more often, but patch size and frequency is speculative and the few studies which have been done are inconclusive regarding quantification of size, frequency or intensity. Lightning ignitions may be more likely in pre-settlement lodgepole pine forests but conclusive evidence is lacking.

At least 350 vertebrate animal species and 1150 vascular plant species occur on the MBNF. Migrating or wintering bald eagles and peregrine falcons are the only federally listed animal species found on the MBNF. There are no federally listed plant species known. Five vascular plant species and 34 vertebrate animals are on the Region 2 senstive species list. Twenty-two (former) USFWS Candidate species ae known. Lynx, wolverines, fishers, ringtails, swift foxes, Preble's jumping mice, yellow-pine chipmunks, spotted bats, whooping cranes, western snowy plovers, black backed woodpeckers, Harlequin ducks, arctic graylings and sturgeon chubs are not believed to presently occur. Grizzly bears, wolves and black footed ferrets are of historical occurrence.

By the late 1800s elk, and bighorn sheep had been extirpated by market hunting. Deer and antelope populations were low. Elk and bighorn sheep were reintroduced after the MBNF was established. All four species are present now. Beavers had been eliminated from the Sherman Mountians sometime before 1920. They were reintroduced late in that decade.

Between 40 and 50 percent of the known populations of Colorado River cutthroat trout are found on the west side of the Sierra Madre Mountains in tributaries of the Little Snake River.

Native Americans used the mountains for lodgepole pines and relgious purposes. Grassland and shrubland areas yielded pasture for horses, berries and other plant products. Native American use appears to have been mostly along travel routes, in canyons and valleys and along the transition to the plains and Great Basin. Trade routes through the Laramie Mountains, Sherman Mountains and southern Medicine Bow Mountains were well established before the mid-1800s. A large fire in the Battle Creek Valley of the southwestern Sierra Madre occurred in 1841 after a battle between fur trappers and Native Americans.

Plentiful supplies of ponderosa pine and lodgepole pine in the Laramie Mountains and Sherman Mountains, near wagon and railroad routes on the Great Plains and Laramie Basin, were used mainly after the 1830s when Sublette built the trading post that later became Fort Laramie. Cutting of ties for the Union Pacific Railroad began on a large scale in 1867 in the Medicine Bow Mountains where ties were floated down streams to Fort Fred Steele where the railroad crossed the North Platte River north of the Medicine Bow Mountains. Tie hacking and tie driving affected most tributaries to the North Platte in the Sierra Madre and Medicine Bow Mountains until the early 1940s. Hard rock and hydraulic mining was locally important in the southern Medicine Bow Mountains and Sierra Madre Mountains from about 1870 to 1910. A few small mines operated in scattered locations in the Laramie Mountains during the same time period.

Forest fires were common and widespread during the 1850-1900 era. About 63 per cent of the forests in the Sierra Madre and 47 per cent of the forests of the Medicine Bow Mountains are approximately 100 to 150 years old. Older forests (200-400 years old) are at higher elevations or in riparian areas, especially in the Medicine Bow Mountains. Clearcutting since 1950 has altered forest landscape age patterns, particularly in higher elevation forests older than 150 years.

Forest Reserves and National Forest administrative units were formed between 1900 and 1908. Early managers were concerned with livestock distribution and numbers, slash cleanup from a half-century of unsupervised logging and fire suppression. Most timber harvest in the Sierra Madre and Medicine Bow Mountains, until after World War II, was for railroad ties and mine props.

Various methods of partial cutting were mainly used. After 1945, clearcutting became the dominant harvest method, many roads were built and recreation uses (especially motorized recreation) increased.

In the Laramie Mountains, timber harvest was mostly localized in the Russell's Camp and Esterbrook areas in the past century. Little harvest has occurred in the Sherman Mountains. Forests there have mostly regrown since the 1860s.

A mountain pine beetle epidemic (1988-1994) in the Laramie Peak area substantially reduced the number of mature and old growth ponderosa pine. Lodgepole pine was affected very little in that epidemic. Although mountain pine beetles are endemic to all mountain ranges of the MBNF, it appears that major epidemics in lodgepole pine are unlikely because brood synchrony may be inhibited by climate. Dwarf mistletoe infections of lodgepole pine varies from absent to severe in the Medicine Bow and Sierra Madre mountains, but is absent to light in the Laramie and Sherman Mountains. Spruce budworm and spruce-beetles do not appear to be serious insect pests here.

In summary, the biological diversity of the MBNF can be understood only by examining similarities and differences among the four mountain areas and the watersheds or elevation zones within them. Diversity is obscured by forest-wide totals or generalizations. Some places have unique species (the Laramie Columbine near Laramie Peak; Colorado River cutthroat trout in the North Fork of the Little Snake River; relictual or disjunct plants at high elevations or the midwest); the character of vegetation composition is different between the eastern ranges with Great Plains and Front Range floristic affinities and the Sierra Madre with western slope and Great Basin floras; kettleholes and the limited high elevation alpine and subalpine island around Medicine Bow Peak and the associated old spruce-fir forests offer special biological diversity to the MBNF.

At present the MBNF has four wilderness areas in two of the four mountain ranges. The four wilderness areas total about 7% of the net NFS acreage. Two canyons are included in wilderness areas. There is one 700 acre research natural area (spruce-fir forest). Several small special interest areas were established in the 1985 Forest Plan. Designated old growth consists of isolated patches in a matrix of age-fragmented forests. Roadless areas consist of a variety of forest types and age classes. Roadless areas comprise approximately 25 percent of the net NFS acres in the Medicine Bow Mountains; 41 percent of the Sherman Mountains; 51 percent of the Laramie Mountains and 54 percent of the Sierra Madre Mountains.

Future choices for biological diversity and ecological integrity of the MBNF landscape and species are constrained by past events, but many choices still remain to managers during this final decade of the first century of National Forest management.

GUIDE TO USING THIS REPORT

INTENT OF THE REPORT

This report is intended as a source, or reference, document about the biological diversity and ecological integrity of the Medicine Bow National Forest (MBNF). The Routt and Medicine Bow National Forests were administratively combined in February, 1995. This report is concerned only with the Medicine Bow portion of the Medicine Bow-Routt National Forest. Reference to the Medicine Bow National Forest (MBNF) in this report refers only to the portion of the Medicine Bow-Routt National Forest located in Wyoming.

This report will serve as an information base for the preparation of other documents such as the biodiversity assessment chapter in the DEIS for the imminent Forest Plan Revision, for project reports, and for monitoring. It will contribute to understanding the past and present as a part of planning the future and serve as a base document for existing condition for discussions with other agencies and the public. It makes available, in a single document, a wealth of information about the species, ecosystems, and history of the MBNF. It is intended to provide a minimum level of information pertaining to the general subjects of biological diversity and ecological integrity. The differences between biological diversity and ecological integrity are discussed in Chapter 2. It makes available a broad array of pertinent literature.

It should be noted that this report on biological diversity and ecological integrity is a staff specialist report. As such it contains evaluations of existing condition of biological diversity and ecological integrity based on interpretation of data and expert judgment. Items are identified for consideration by planners and managers. We recognize that information is lacking in many areas. In this report effort is made to identify critical information gaps, to clearly separate site-specific data from broad-scale data, and to separate data from interpretation and inference.

Identification of problems, considerations and interpretations by the specialists who authored this report are not necessarily endorsed by the Medicine-Bow Routt Administration or the Forest Plan Revision Team. Rather, these identifications, considerations, and interpretations are a component of the information and opinion which is part of the disclosure required by the National Environmental Protection Act (NEPA process). It represents part of the input available for forest and project planning at the time of preparation (1995). As new information becomes available, considerations and interpretations may necessarily change.

ORGANIZATION OF THE REPORT

The report has ten chapters and 21 appendices. The text length of the ten chapters is approximately 25% of the document. The rest is tables, figures and literature citations.

Chapters 1 and 2 provide information on the general subjects of biological diversity and ecological integrity at national, regional and local levels. Issues on the MBNF identified during Scoping Effort of the Plan Revision Process in 1993 are presented. These chapters also provide information on ecological theory, especially with regard to scales and process, and the relationship of biological diversity to other topics.

Chapter 3 provides the physical framework for biological diversity on the MBNF, including geology, climate and land classification. Chapters 4 and 5 respectively present historical information and a photographic essay depicting major ecosystems and effects of human activity on communities and landscapes.

Terrestrial ecosytems are discussed in Chapter 6. Aquatic and riparian ecosystems are discussed in Chapter 7. Species and genetic level concerns (fine filter information) as well as information on big game herbivores and large predators is in Chapter 8. Chapter 9 is devoted to Roadless Areas, Wilderness Areas and Research Natural Areas. The Old Growth Patch and Linkage System is presented as a strategy for management of old growth and late successional forest in forested landscapes with age fragmentation. Chapter 10 includes identification of problems and considerations for planning and management of biological diversity and ecological integrity.

For Chapters 1-10, tables are integrated into the text for easy reference. Figures are grouped at the end of the chapters. This was necessary because of production limitations and because the color maps must be single-sided. In the Appendices, both Tables and Figures are at the end of the text and literature cited sections.

This report provides a multiscale view of biological diversity and ecological integrity at four spatial scales. These are:

Coarse Filter Scale

1. The Landscape Scale: a) the MBNF as part of the larger set of regional ecosystems, and b) smaller landscape systems within the Forest Administrative Area

2. The Community Scale defined in terms of watersheds, vegetation communities or animal guilds

3. The Species Scale: a) lists of all known vascular plant and vertebrate species by mountain area, and b) specific information on Federally Threatened, Endangered species and Region 2 - Sensitive Species. (Labels for former C2 or C3 (Candidate) species were retained)

4. The Genetic Scale (where information is available) for example for Colorado River cutthroat trout.

The landscape is organized into multiscale spatial units by watersheds (Biodiversity Units or BDU's) and groups of watersheds (Biodiversity Areas or BDA's). This is explained in Appendix 2. There are 96 watersheds (BDU's) identified in the report. These are aggregated into 16 groups (BDA's). Both the watersheds and groups of watersheds in turn, nest spatially into the mountain ranges. Tabular aata are aggregated upward to biodiversity areas, mountain ranges and forest-wide sums or per cents. Map information is displayed with a background grid of BDA's and BDU's to permit comparison of specific watersheds among maps and to correspond with the watershed tables. Thus, the resolution for most of the landscape level data (cover type, stand age, structural stage, timber harvest patterns, occurrence of some species) is presented at the watershed level and aggregated upwards to groups of watersheds, to mountain ranges and forest-wide.

INFORMATION SOURCES

Landscape metrics analyses were done on the basis of watersheds and the results aggregated upwards (Baker 1994). It is expected that the system of BDU's and BDA's will be similar to the Geographic Areas used later in the Forest Plan Revision. In any event, they provide a consisent, watershed-based framework into which data are placed and maps created. It provides a tool to evaluate cumulative effects.

Time is also scaled. Temporal Scales include: 1) Geologic Time, and 2) Historical Time. Historical Time is divided into five periods. These are the years 1550-1799; 1800-1849; 1850-1909; 1910-1949; 1950-1994. These five time periods were chosen with regard to the length of time recorded in the oldest known forest stands and reference to human activities.

Integration of time and space scales related to ecological information is often one of the most difficult parts of the process which generates understanding of ecosystems (Allen and Hoekstra 1992).

Historical information was obtained by searching the Government Documents sections of the libraries at the University of Wyoming and Colorado State University. Limited searches of museums were also done. The extensive Medicine Bow Collection at the American Heritage Center, University of Wyoming, was a major source of historical information.

Data on forest pattern and landscape structure are extracted from the Medicine Bow National Forest Resource Information System (RIS) database, current through approximately November, 1994. Data on occurrence of Threatened, Endangered, Candidate, and Region 2 Sensitive species (TECS) are from Wyoming Game and Fish Department records, the Nature Conservancy Wyoming Natural Diversity Database, consultant reports, graduate research, University studies and MBNF Staff Specialist reports. The U.S. Fish and Wildlife Service discontinued the recognition of Candidate Species Categories 2 and 3 (C3 and C3) on July 19, 1995. The USFWS has requested continued support from other agencies for protective measures for former C2 species (Davis, 1995). Both C2 and C3 species were identified in the draft of this report in May, 1995. The C2 and C3 designations are retained as labels to help identify these as species of concern.

Recent reports by consultants support this report. These reports and analyses include:

1) A landscape metrics analysis, believed to be the first of its kind, on the Sierra Madre and Medicine Bow Mountain Ranges was done by Dr. William Baker, University of Wyoming Department of Geography (Baker, 1994). Landscape structure as currently portrayed in the RIS (Resource Inventory Database) of the Medicine Bow National Forest was interpreted. Items assessed include cover type, forested stand age, forest structure, patch size number, and density of patches. Disturbance regimes since 1950, including clearcutting, partial cutting, fire, and blowdown were assessed. Old growth was defined using stand age, structural stage, and Old Growth Scorecard data and interior area was estimated using an edge effect circumscription of 60 meters (about 200 feet) inside existing edges.

2) Ecological evaluations for 12 potential research natural areas (Jankovsky-Jones et al. 1995) were prepared by the Wyoming Natural Diversity Database staff. The Establishment Report for the Savage Run (1989) and the Environmental Assessment for Ashenfelder Basin (1992) are two other documents, prepared by the MBNF, for proposed Research Natural Areas.

3) A fine filter report on Federally Threatened, Endangered, Candidate, and Region 2- Sensitive Species at the Ecoregion scale was prepared by the Wyoming Natural Diversity Database (Mills and Neighbors 1995).

Other recent work done by MBNF staff includes the Old Growth Inventory and Analysis; the Fire History Analysis; the Biological Diversity of Succession in Clearcuts project; the Lichen Inventory; Biological Evaluations for Threatened, Endangered, Candidate and Region 2-Sensitive plant and animal species by District Biologists; watershed health evaluations, and identification of watersheds of concern. These reports are in the Appendices.

An unusually excellent source of information on the biological and physical diversity of the Medicine Bow National Forest is the cumulative knowledge contained in nearly 900 documents by graduate students, University faculty, Forest Service researchers, Wyoming Game and Fish staff, and National Forests staff since about 1910. These include studies done within the boundaries of the Medicine Bow National Forest, studies in which the Medicine Bow was one of several locations, and studies on similar major ecosystems nearby in northern Colorado (Fraser Experimental Forest, Routt National Forest, Arapaho-Roosevelt National Forest). A major effort was made to locate and review these documents. They are listed in Appendix 1, Bibliography of Scientific Studies, by topic. Many are cited throughout the report.

This report will provide a foundation for describing and classifying biological diversity. It will help to differentiate degrees of ecological integrity It may suggest more questions than it answers, and it should be a foundation for further investigations. It provides material for discussion to foster constructive debate contributing to the efforts of Ecosystem Management.

LITERATURE CITED

Allen, T.F.H.; Hoekstra, T.W. 1992. Toward a Unified Eoclogy. Columbia University Press.

Baker, W.L. 1994. Landscape Structure Measurements for Watersheds in the Medicine Bow National Forest using GIS Analysis. Department of Geography and Recreation. University of Wyoming, Laramie, WY. Contract with Medicine Bow National Forest. Laramie, WY.

Davis, C.P. Oct. 12, 1995. Letter from C.P. Davis, Field Supervisor, Wyoming Field Office of the U.S. Fish and Wildlife Service to Forest Supervisor Jerry Schmidt regarding the status of former C2 and C3 species.

Jankovsky-Jones, M.; Jones, G.P.; Fertig, W. 1995. Ecological evaluations for potential Research Natural Areas (Twelve Separate Reports). Prepared for the Medicine Bow National Forest under contract by the Wyoming Natural Diversity Database, Laramie, WY.

Mills, S.; Neighbours, M. 1995. Intensive Data Gathering Project (Fine Filter Analysis) for occurrences of rare, threatened, endangered and sensitive species in Sections M331H and M331I, North Central Highlands and Northern Parks and Ranges, in Wyoming. Contract with the Medicine Bow National Forest, Laramie, WY.

PREFACE

This report is a story of the ecosystems of the Medicine Bow National Forest and the people who lived in and managed those ecosystems in the past - Native Americans, tie hackers, miners, ranchers, trappers, Forest Rangers, and Forest Supervisors. We who prepared this report, and those who use it, will also become part of this story - for today's discussions and actions become tomorrow's history.

This report is intended to be a bridge in the present (1995) to enable a better understanding of the past, by those who mold the future. It is an information tool for biological diversity and ecological integrity.

The information available in this report is the result of thousands of hours of work by hundreds of people over most of the past century - people who have given and are giving time, patience, and their best efforts to learn about the biological, physical, and historical environment of the Medicine Bow National Forest. These people include Forest Service Researchers and Staff, University Professors and Students, Game and Fish Personnel, and Consultants and Researchers in the private sector. They have climbed mountains, dug holes, collected specimens, and gathered data from instruments. They have looked at a wide range of phenomena - from soil bacteria to weather patterns, from plants to fish, from activities of people to activities of insects, from processes affecting leaf surfaces to patterns discerned by satellites.

This report presents their scientific data, scientific information, and scientific knowledge. The information is well documented from the literature of ecological science including such peer-reviewed journals such as *Vegetatio*, *Ecological Monographs*; *Ecology*, *The Journal of Ecology*, *Landscape Ecology*, *Bioscience*, *American Midland Naturalist*, *The Great Basin Naturalist*, and *Conservation Biology*. Literature from more specialized publications such as the *Journal of Forestry*, *Forest Science*, and *Journal of Range Management*, as well as Forest Service Research Branch Publications are also well-represented. Graduate research projects, consultant reports and conference proceedings also provided information.

Some of the ideas presented in this report challenge ideas which have been around a long time in Forest Service Management. Some new ideas are presented. Many are based in the relatively new disciplines of Landscape Ecology and Conservation Biology. New perspectives for planning and management are fundamental reasons for preparation of this report.

PRODUCTION CREDITS

Medicine Bow National Forest, Laramie, WY
United States Department of Agriculture, Forest Service

PREPARERS

Name	Title	Credentials
Senior Author, Editor		
Dr. Judy von Ahlefeldt	Forest Ecologist	PhD (Landscape Ecology)
Riparian and Aquatic Information		
Clay Speas	Forest Fisheries Biologist (to October, 1994)	MS (Aquatic Ecology)

ACKNOWLEDGMENTS

Special thanks are due to:

Tim Byer. USFS Biologist, Douglas Ranger District. Animal species lists, big game information.

Bob Daniels. USFS Biologist. Species abstracts, big game information.

Shirlene Haas. USFS Biologist, (former) Hayden District. Development of old growth patch and linkage system.

Joel Harper. USFS Biologist, Laramie Ranger District. Animal species lists, big game information, old growth patch and linkage system development.

Jerry Mastel. USFS Ecologist, Brush Creek-Hayden District. Animal species lists, big game information, old growth patch and linkage system development, species abstracts.

Sally Tinker. USFS Technician, data assembly and Appendix on Neotropical birds.

Carol Tolbert - USFS, GIS analysis and map preparation.

Marla Wertz - USFS, graphic art support.

Others who assisted in data assembly, table and appendix preparation, proofreading, editing, review, field work or other tasks are:

Medicine Bow National Forest:
Tom Cartwright - Forest Wildlife Biologist
Dee Hines - Forest Analyst
Phil Krueger - Forest Silviculturalist
Larry Lindner - Monitoring Staff
Ron Olsen - (Former) Resources Staff Officer
Marc Wilcox - Forest Hydrologist
Vicki Whitten-Dowse - Forest Soil Scientist
Art Foster - Biological Technician
Leslie Horsch - Hydrology Technician
Vicki Leonard - Fisheries Technician
Patrick McLaughlin - Biological Technician
Jay Newton - Hydrology Technician
Greg Eaglin - Zone Fisheries Biologist Medicine Bow/Routt NF
Terry DeLay - Forester - Brush Creek - Hayden District
Pam Frei - (Former) Fisheries Biologist - Laramie Ranger District
Steve Kerpan - Wildlife Biologist - Brush Creek-Hayden District
Joe Remick - Range Conservationist - Hayden District
Deana Wood - Archaeologist - Laramie District

Rocky Mountain Forest and Ranger Experiment Station (RMFRES):
Hank Henry - RMFRES Laramie, WY
Dr. Will Moir - RMFRES Fort Collins, CO
Dr. John Squires - RMFRES - Laramie, WY
Dr. Mike Young - RMFRES - Laramie, WY

Wyoming Game and Fish Department (WY G&F):
Mark Fowden - Wyoming Game and Fish Department
Mike Snigg - Wyoming Game and Fish Department
Reg Rothwell - Wyoming Game and Fish Department

University Staff and Students:
Dr. Greg Hayward - Department of Zoology, Univ. WY
Dr. Steve Miller, Department of Botany, Univ. WY
Dr. Larry St. Clair - Monte L. Bean Museum, Cryptogam Herbarium, Brigham Young University, Provo, Utah
Dr. Sam Sushan - Lichenologist, Univ. of Colorado, Boulder, CO
Dr. Steve Williams - Dept. of Plant Soil and Insect Sciences, Univ. WY
ZhiPeng Zhso - Graduate Student Dept. of Plant Soil and Insect Sciences, Univ. WY.

Other:
Bill Brenneman - Lichenologist, lichen identification
Tim Chumley - Student, Univ. WY Preliminary lichen identification
Dr. Dan Hausel - Geologist, Geological Survey of Wyoming
Dick Roth - Region 2 Neotropical Migratory Bird Specialist

This report was Peer-Reviewed by:

Dr. Dennis Knight - Botany Department - University of Wyoming
Dr. Richard Knight - Fisheries and Wildlife Department - Colorado State University - Fort Collins, CO.
Dr. Richard Laven - Forestry Sciences - Colorado State Universty - Fort Collins, CO.
Dr. John Schmid - RMFRES (retired) - Fort Collins, CO.

CHAPTER 1

INTRODUCTION

PURPOSE

The purpose of this report is to describe and interpret the biological diversity and ecological integrity of the Medicine Bow National Forest using the most complete information and advanced technical analysis tools available. The report should convey to the reader the historical and present condition of biological diversity and ecological integrity, and provide sufficient information to understand these concepts and the issues surrounding them in national, regional, and local contexts.

DEFINITIONS OF BIOLOGICAL DIVERSITY

Biological diversity has been defined in several ways (Table 1.1). The definitions have in common the description of the variety of life in ecosystems. They differ by emphasis on processes and recognition of temporal and spatial scales. Consideration of these three agency definitions of biological diversity reveals recognition not only of species population structure and composition, but also multiple scale considerations from genes to large landscapes and the importance of processes and functions. Processes and functions which cause change in biological diversity over time in defined spatial areas are important considerations for management. The R-2 definition is used for this report.

BIOLOGICAL DIVERSITY AND ECOLOGICAL INTEGRITY

There are important distinctions between the concepts of biological diversity and ecological integrity. Ecological integrity is a subset of biological diversity. While biological diversity recognizes the variety of life and its processes, ecological integrity differentiates among the kinds of organisms and processes represented. Ecosystems with ecological integrity have near-natural conditions for four broad ecosystem characteristics: 1) productivity, 2) biodiversity of native plants and animals, 3) soil condition, and 4) water condition. The ecological integrity of ecosystems may be their most sensitive attribute (Forman 1995).

Changes in biological diversity can often be evaluated only by changes in ecological integrity. Any change in an ecosystem may be interpreted as a gain or loss of biodiversity, however, if the change is toward or away from conditions characteristic of native ecosystems, then gain or loss of ecological integrity can be evaluated (Angermier and Karr 1994).

Table 1.1 Definitions of biological diversity

Source	Definition
OTA (1987)	Biological diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequencies. Thus, the term encompasses different ecosystems, species, and genes and their relative abundance.
R-2 (1992)	Biological diversity is the full variety of life in an area, including the ecosystems, plant and animal communities, species and genes, and the processes through which individual organisms interact with one another and with their environments.
BLM (1988)	Biodiversity is the aggregate of species assemblages (communities), individual species, and genetic variation within species and the processes by which these components interact within and among themselves. For purposes of classification, biodiversity can be divided into three levels: community diversity (habitat, ecosystem), 2) species diversity, and 3) genetic diversity within species. All three levels change with time.

OTA (Office of Technology Assessment); R-2 (Biological Diversity Assessment for the Regional Guide - Rocky Mountain Region, USDA Forest Service); BLM Advisory Committee, 1988 Davis, CA.

Near-natural conditions means that ecosystems have not been altered very much by human actions. Ecological integrity, for example, can be measured by the number of native species and ecosystems, while biological diversity may include non-native species and ecosystems which develop because of human activities. Another example would be an agricultural field with a high annual input of fertilizer used to grow a non-native crop. This ecosystem would have definable biological diversity characteristics, but would lack ecological integrity because of the alteration of productivity, species composition, and soil conditions by human activity.

Ecological integrity refers to maintaining a suite of organisms and processes characteristic of ecosystems prior to manipulation by modern technological man. For example, in aquatic systems, an important aspect of maintaining ecological integrity may mean perpetuation of native trout species populations. Such a management goal may result in less biological diversity for a given stream reach if only numbers of species are used as the biological diversity criterion. If the native trout and their habitat are maintained, then both the overall biological diversity and biological integrity of the landscape increases because native trout provide both an added species and a component of native ecosystem charact2eristics. In forests, ecological integrity may refer to maintaining populations of native species depending on, or preferring, old growth forest habitat as a component of biological diversity of the larger ecosystem of which those sites are a part.

In the broadest context, biological diversity refers to both native and introduced species and ecosystems on the landscape. Because many of the introduced species are socially, economically or politically desirable, biological diversity in this report recognizes all species. Appropriate discussion will be given to situations where non-native species are competing with, or replacing, native species. The NFMA considers desirable introduced species to be within the management arena for diversity (36 CFR 219.27g (Federal Register 1982).

BIOLOGICAL DIVERSITY AND LIFE

Biological diversity is important because it is the substance upon which biological evolution operates. The greater the diversity in landscapes, communities, species and genes, the greater the choices for adaptation to change. If the diversity includes non-native species, then there is the possibility that ecological integrity will be compromised. When biological diversity is low, and ecosystems are simplified, fewer outcomes are possible and there is a higher probability that chance events could cause ecosystem changes.

Biological diversity provides the framework from which socially and economically acceptable ecosystems are derived. Essential attributes of ecosystems are their biological diversity, ecological integrity, productivity, and sustainablity. These are related in complex ways not well understood despite years of research on relationships among these attributes. However, it appears clear that to achieve future consistently productive and sustainable ecosystems, the desired components of these ecosystems must be maintained above some level where fluctuations of environmental variations at different scales can be accommodated without disastrous feedbacks (Moir 1995).

BIOLOGICAL DIVERSITY ISSUES

In the winter of 1993, the Medicine Bow Forest Plan Revision Team conducted a scoping analysis among Medicine Bow National Forest and District Staff, state agencies, political and industry groups, conservation groups, and the academic community at the University of Wyoming to develop a set of issues for the Forest Plan Revision. Biological diversity was one of the major topics identified for the Plan Revision.

Below are major biological diversity issues. Some of these also address concerns for ecological integrity. (Purpose and Need Document - MBNF Forest Plan Revision 1993):

1. Fragmentation of the structure and age classes of forested ecosystems due to roads and timber harvest.
2. Connectivity among fragmented habitats.
3. Depletion of old growth forests, especially in high-elevation spruce-fir types.
4. Adequate interior area of mature and old-growth forests.
5. Effect of post-treatment timber harvest practices on biological diversity (for example rollerchopping).
6. Effects of timber harvest practices other than clearcutting on biological diversity (for example partial cutting).
7. Riparian condition (especially in the Laramie Mountains)
8. Wildlife population levels (overpopulation of game species; population depletion of other species).
9. Effect of livestock grazing on biological diversity.
10. Monitoring of biological diversity.
11. Relationship of biological diversity to forest health and watershed health.
12. Conservation of habitat for Threatened, Endangered, Candidate, and Sensitive species.
13. Restoration of both aquatic and upland habitats degraded from previous management practices unacceptable by today's standards.
14. Fire management.

These issues and other topics are addressed in this report.

NEED FOR THE REPORT

Preparation of this report was requested in 1993 by former Forest Supervisor Gary Heath, after a similar report was prepared for the Thunder Basin National Grassland (von Ahlefeldt et al. 1992). That report was prepared to address biological diversity description and evaluation for the Oil and Gas Leasing EIS (USDA Medicine Bow National Forest 1992).

OTHER REPORTS ON BIOLOGICAL DIVERSITY

Prior to, or concurrent with that report, a few biological diversity analyses had been done in other areas of the country (USDA Beaverhead National Forest 1991; George Washington National Forest - Virginia Dept. of Conservation and Recreation 1991); Blue Mountains - Healy 1992). Some other recent major documents addressing biological diversity issues for areas larger than a National Forest Administrative unit include the report on the Northen Spotted Owl (Thomas et al. 1991); the Greater Yellowstone study (Greater Yellowstone Coordinating Committee 1987) and the Forest Ecosystem Management Assessment Team Report (FEMAT 1993) for the Pacific Northwest National Forests.

At the National Forest Level, the 1991 George Washington National Forest Biodiversity Report, prepared under contract by the Nature Conservancy, consisted of site reports for proposed Research Natural Areas (RNA) and Special Interest Areas (SIA). The Trail Creek Supplemental Report for the Beaverhead National Forest, (USDA 1991) was prepared for a timber sale FEIS by an interdisciplinary team within Region 1. This report introduced the concept of the Range of Natural Variability (RNV) as a component of evaluating management impacts on landscape-scale biological diversity. The Blue Mountains Report (Healy 1992) was an inter-forest effort in Region 6 to develop a large-scale assessment of a group of ecosystems managed by several forests. This report introduced semi-quantitative models of RNV and some techniques of historical inference.

Since 1992, Forest Service approaches to describing biological diversity, or matters relating to it, such as the Range of Natural Variability, have included efforts on specific National Forests (examples: San Juan National Forest 1993; Rio Grande National Forest 1994; Klamath National Forest 1993; Black Hills National Forest 1993; Routt National Forest 1993) as well as large Regional Assessments such as the Columbia River Basin Ecosystem Management Assessment currently in progress (Science Integration Team 1994).

A series of white papers to guide Ecosystem Management, prepared by expert interdisciplinary teams consisting of Forest Service scientists, members of the scientific academic community, conservation leaders, and industry representatives has been initated (example: Morgan et al. 1994). Other recent assessments on the status of specfic species or groups of species include Ruggiero et al.(1994) on lynx, marten, fisher and wolverine; Hayward and Verner (1994), on forest owls, and Young (1995) on inland cutthroat trout.

A draft *National Framework for Integrated Ecological Assessments*, a product of two protocol teams (Bio-Physical Assessment Team and Human Dimensions Assessment Team) which comprised an interagency working group under the sponsorship of the White House Council on Environmnetal Quality, was completed in October, 1995. This document goes beyond the description and evaluation of biological diversity and ecological integrity. It suggests a framework for policy-relevant ecological assessments at national and regional scales (CEQ 1995).

The status and trends of biological diversity in the United States was reviewed by Langner and Flather (1994). They concluded that native plant and animal diversity has declined over the past three decades and is likely to continue to decline because of continuing human population growth and associated development.

JUSTIFICATION FOR BIOIOGICAL DIVERSITY CONCERNS

LAW

Legal requirements, direction, and guidelines for management of biological diversity on Federal Lands come from three sources: law, policy, and precedent. Article I of the U.S. Constitution (Legisative Branch) authorizes Congress to make laws such as the Endangered Species Act, the National Forest Management Act, or the Clean Water Act. Legislative direction for conservation of biological diversity in the United States (Table 1.2) began with state game conservation laws and the Creative Act of March 3, 1891 (Runte 1991; USDA 1993). The Creative Act empowered U.S. Presidents to designate Timber Reserves for the purpose of preserving and protecting public lands. It was a reaction to the rapid cutting of forests on public land at that time. Conservation at the species level was the subject of earlier laws. Later legislation addressed conservation of watersheds and rivers. Legislation to conserve biological diversity of entire ecosystems was introduced into Congress during the late 1980s and early 1990s (Blockstein 1990).

Management and protection of watersheds is addressed by the 1897 Organic Administration Act (16 USC 475), the 1987 Clean Water Act (33 USC 1251), the

National Forest Management Act (16 USC 1600), and the 1973 Endangered Species Act (16 USC 1531). Compliance with two of these (Clean Water Act and the Endangered Species Act), is required at all levels of government and by private citizens. These laws are to protect productivity, ecosystem function, water quality, and diversity.

Although the term "diversity" with reference to plant and animal species and communities appears in laws and regulations which govern the Forest Service, the term "biological diversity" does not appear directly in the National Forest Management Act (1976); the Multiple Use and Sustained Yield Act (1960); the Clean Water Act (1948, 1973, 1987); the National Environmental Policy Act (NEPA) (1969), or the Endangered Species Act (1973, 1982). "Biological integrity" is part of the language of the Clean Water Act. If the word "diversity" is interpreted to refer to "biological diversity" or "ecological integrity" where the subject is native or desired non-native living organisms or communities, then directions for management of elements of biological diversity and ecological integrity appear throughout these laws (Boyce 1981; USDA 1993; Keiter 1989; Keiter 1990; Sample 1991; Congressional Research Service 1992; Titus 1992).

Table 1.2 **Synopsis of major legislation to conserve species and ecosystems** (Adapted from Cooperrider 1991).

Species	Legislation
Large game mammals, birds & fish (1700s)	State Game Protection Laws
Wild animals	Lacey Act (1900)
Wild birds	Migratory Bird Treaty Act (1918)
Fish	Fish Restoration and Management Act (1950)
Plants & animals	Endangered Species Act (1973)
Ecosystems	**Legislation**
Forest Lands	Forest Reserve Act (1891)
Grazing Lands	Taylor Grazing Act (1934)
Wildlife Sanctuaries	Fish & Game Sanctuary Act (1934)
Wilderness	Wilderness Act (1964)
Rivers	Wild and Scenic Rivers Act (1964)
Coastal Areas	Marine Protection Research and Sanctuaries Act (1974)
Forest Lands	National Forest Management Act (1976)
Rangeland	Federal Land Management and Policy Act (1976)
All Lands	Multiple Use and Sustained Yield Act (1960)
	National Environmental Policy Act (1969)

POLICY

Article II of the Constitution (Executive Branch) authorizes the President to execute laws by executive orders. It also authorizes Agencies to implement the laws through Regulations, published in the Federal Register and written in the Code of Federal Regulations (CFR). Regulations are derived from law and bear the force of law. Official internal agency policy, practices and procedures are found in Forest Service Regulations (36CFR), and the Forest Service Manual (FSM) and Forest Service Handbook (FSH) and supplements to both. The FSH and FSM consitute the Directives system and are also derived under Article II (Executive Branch) of the Constitution.

Directives (written in the FSM and FSH) and direction (instructions for executing programs) both fall partly into the realm of law and partly into the realm of policy. Directive wording determines how binding the direction is. "Must" and "shall" convey mandatory compliance, "ought and should" convey required compliance except for justifiable reasons, while "may" and "can" convey optional compliance (USDA 1995). Service-wide Direction is issued on white paper by the National Level, Regional Supplements to Service-wide direction are on blue paper, and Forest Supplements are on green paper. Research Station Directors may also supplement Service-wide direction. Line officers at most administrative levels from the Chief through District Rangers have authority to issue direction for programs under their jurisdiction (USDA 1995). Thus, in the realm of official policy, there is considerable latitude for administrators to influence management of biological diversity and ecological integrity.

Unofficial policy, expressed by Management at different levels through talks and publications, may not be as binding or influential as Service-wide direction from the Chief via a white paper, Regional Supplements, Forest Supplements, or Research Station Supplements, but it still influences the management of biological diversity and ecological integrity on public lands.

National Policy

New approaches and ideas for management of biological diversity and ecological integrity have co-evolved with official and unofficial policy, precedent, debate, and new information. Policy of both types has come from many sources: from directives, from amended regulations, from the President, the Courts, the Chief, Regional Foresters and Research Station Directors.

Some particularly influential policies and approaches to conserve biological diversity are summarized in the following events and actions.

In April 1993, President Clinton convened the Forest Conference in Portland, Oregon, in response to the deadlock over the conservation of the spotted owl and old growth forests, concurrent with the increasing demand for forest products. The plan that emerged for that area included using watersheds as the fundamental units to describe, manage, and monitor biological diversity; reserve areas for old growth and the kinds of biological diversity associated with it; and several experimental approaches to find solutions to conservation/economic problems (FEMAT, 1993). The December, 1994, court decision to uphold this plan has many implications for the management of biological diversity on all NFS lands (Seattle Audubon vs Lyons 1994).

Appeal decisions by the Chief of the Forest Service are another avenue by which policy may be affected. *An Analysis of the Chief's Decisions on Selected Appeals* (Kirby and Laner 1989) was done by the Pacific Southwest Research Station. Some policy areas affected by these decisions which concern biological diversity include: use of ASQ levels, choice of silvicultural systems, non-wilderness allocations, development of roadless areas, consideration of species diversity in the planning process, old growth habitat, and old growth timber.

Some examples of national strategies to maintain biological diversity or ecological integrity developed within the Department of Agriculture and the Department of Interior are:

****

USDA Forest Service. 1991. *Conserving Our Heritage: America's Biodiversity.* USDA Washington, D.C.

- land management, land exchanges
- research
- cooperative programs
- Research Natural Areas and biological inventories
- publications, conferences, public awareness

****

USDI, USDA. 1992. *America's Biodiversity Strategy: Actions to Conserve Species and Habitats.* Preprint 5/15/92. Washington, D.C.

- reducing habitat loss
- establishng specially protected areas or habitats
- restoring degraded habitat and controlling non-native species
- laws and policies to conserve individual species or groups of species
- statutes, regulations and policies to reduce pollution
- captive breeding and genetic conservation
- partnerships, international cooperative programs
- support of basic research on biodiversity conservation

****

USDI. 1993. *Ecosystem Management in the BLM: A Process to Promote Biological Diversity and Sustainable Development.* Draft Concept Paper for Public Comment. March, 1993. Washington, D.C.

****

Kaufmann, M.R. et al. 1994. *An Ecological Basis for Ecosystem Management.* USDA Forest Service General Technical Report RM-246

- ecosystem needs assessment
- reference conditions
- existing conditions
- coarse filter and fine filter evaluation
- integrating ecosystems and human needs

Policy also can be articulated through Forest Planning documents. The 1990 Recommended Resources Planning Program (RPA) contains direction for recognition and perpetuation of biological diversity (USDA, 1990).

> The USDA Forest Service has the responsibility to be a leader in the conservation of resources and environmental values of the Nation's forests and rangelands" (S-1). The report cites biological diversity as a subject "where there is considerable uncertainty about the magnitude of future impacts and where knowledge for management is imperfect" (S-11). As a response to the contemporary issue of biological diversity, the direction is that "The Forest Service will increase its role in developing knowledge, implementing conservation measures, and demonstrating management approaches that conserve specific elements of biological diversity (S-18).

The most recent and comprehensive treatment on biological diversity is contained in the *Draft Framework for Integrated Ecological Assessments* (Interagency Protocol Team 1994). The essence of an integrated ecological assessment is to combine historical and ecological analyses. This means a synthesis of ecological principles with existing condition to assess biophysical environments, species viability, vegetation patterns, and aquatic patterns for specific geographical areas.

The New Perspectives program, begun in the late 1980s, evolved into the present Forest Service and Interagency Ecosystem Management Policy. The Ecosystem Management Policy was announced by then Forest Service Chief Dale Robertson on June 4, 1992 (Robertson 1992). This was followed shortly by a decision to reduce clearcutting on the National Forests (June 25, 1992). These policies have been continued under the administration of Chief Jack Ward Thomas (Thomas 1994).

Unofficial policy concerning biological diversity and ecological integrity has been articulated by high ranking Forest Service officials and program directors. Below are some relevant examples:

- George Leonard, former Associate Chief of the Forest Service, talked about the question of acceptable short-term social costs for the long-term investment in a biologically rich future. He said that conserving biological diversity will not be either cheap or without controversy. He said, "If we don't sustain diverse forests and rangelands we will not ultimately sustain meaningful human life." (Leonard 1990)

- Hal Salwasser (1991), director of the New Perspectives program from the Washington Office, said, "We must put conservation of biological diversity into its right and proper context: stewardship of lands and resources to sustain the wide array of values and uses needed by this and future generations.... The goal is, in the words of Aldo Leopold, a state of harmony between people and the land." He also discussed sustainability — sustainability of the environmental security of the region, sustainability of meeting the needs of people for commodities and spiritual growth, and sustainability of the resource for economic development. He said, "...conserving biological diversity is the right thing to do for the land...and it is the right thing to do for people...." Rocky Mountain Regional Biological Diversity Symposium (Salwasser 1991a).

- Former Deputy Chief James Overbay (1992) said, "There is a lot of discussion currently about whether ecosystem management means to preserve the intrinsic values or natural conditions of ecosystems, with resource uses and products as secondary by-products, or whether it means to produce desired resource values, uses, products and services in ways that do not impair the long-term sustainability, diversity, and productivity of the ecosystems. The Forest Service's legal mandate in this issue is clear. For the Forest Service, ecosystem management means to produce desired resource values, uses, and products in ways that also sustain the diversity and productivity of ecosystems. Ultimately this mandate contains neither a product-oriented nor a nature-oriented bias.... Therefore, ecosystem management cannot be reduced to a simple matter of choosing to have either resource products or natural conditions. It must chart a prudent course to attain both of these goals together. This can only happen in areas large enough to allow for compatible patterns of different uses and values in a landscape or region."

- In August, 1993, Assistant Secretary of Agriculture James Lyons testified in support of the Administration's Proposed Northwest Timber Policy. Support for Option 9 recognized the key role of watershed management and

protection of riparian areas for sustainable forest management. Choice of this option sets policy and precedents for how biological diversity may be considered in forest management (Lyons 1993). The recent decision by Judge Dwyer, (Seattle Audubon vs Lyons 1994) to uphold this choice is an important development in the history of how the Forest Service will accommodate biological diversity concerns in Ecosystem Management.

Washington Office Program Directors and Staff have produced a huge literature on federal agency interaction with conservation of biological diversity and ecosystem sustainability in the last seven years. Hal Salwasser, Jerry Franklin, and Winnifred Kessler are three examples of prolific writers and spokesmen for the former New Perspectives Program and the present Ecosystem Management Policy. Much of what they promote is based on conservation of biological diversity.

Some annotated examples of publications in which concern for biological diversity policies are expressed include:

****

Salwasser, H. 1987. Editorial for *Conservation Biology* on strategies to conserve biological diversity. *Conservation Biology* 1(4): 275-277

Three major strategies to be used in combination with different technologies and management approaches:

1. Diversity First
2. Diversity Coequal
3. Diversity Secondary

****

Salwasser, H. 1991b. Some perspectives on people, wood, and ecological thinking in Forest Conservation. Talk presented at various conferences and seminars on New Perspectives in Fall, 1991.

Discussion on sustainability and roles of biological diversity:

A triangle with sides of:
Ecologically Possible
Economically Feasible
Socially Desireable

****

Salwasser, H. (winter) 1991a. New Perspectives in Managing the National Forests and Grasslands Environmental Planning Quarterly 8)3): 8-19.

Five Principles of New Perspectives:

1. meeting people's needs
2. protecting basic resources (including biodiversity)
3. healing the wounds of the past (species and ecosystem recovery)
4. renewing the land with diversity after commodity use or natural events
5. providing opportunities for learning

****

Salwasser, H., MacCleery, D.W., Snellgrove, T.A. 1993. An ecosystem perspective on sustainable forestry and new directions for the U.S. National Forest System. IN: Aplet, G.H., Johnson, N., Olson, J.I. and V.A. Sample (eds.) Defining Sustainable Forestry Island Press. Washington, D.C. pp. 44- 89: Managing ecosystems to conserve diverse, resilient, and productive forests and rangelands is conceptually broader than the previous models of sustained-yield resource management and multiple use.... (page 81)

- Discussion of policy choices implicit in old growth management decisions in the Pacific NW.
- Articulation of biodiversity guidelines:
  1. recover and conserve formally listed threatened and endangered species
  2. provide for viable populations of native plant and animal species
  3. maintain a viable network of native biological communities and ecosystems
  4. maintain structural diversity
  5. sustain genetic diversity
  6. produce and conserve resources needed by people
  7. protect ecosystem integrity - soils, waters, biota and ecological processes
  8. restore and renew degraded ecosystems
- Application of site design at the landscape level

****

Some other articles which discuss roles of managers in conserving biological diversity, sustainability and stewardship are: Salwasser (1991); McMinn (1991); Kessler et al. (1992) and Franklin (1992a).

Forest Service Research has been a leader in suggesting approaches to biological diversity measurement, monitoring and management techniques which may subsequently be accepted by NFS Management and translated into policy. The Research Branch provides information through General Technical Reports, which often are conference proceedings, and through numerous papers and presentations given by Research Station staff (some examples: Thomas 1985; Crow 1991; Bartlett and Jones 1991; Swanson and Franklin 1992; Franklin 1992b).

Regional Policy

The Rocky Mountain Region (Region 2) produced an updated Regional Planning Guide in 1992 which included a separate Regional Biodiversity document. The Desk Guide (for planning - also produced by the Regional Office) is undergoing continual revision to accommodate new approaches to many issues in Forest Planning, including how biological diversity will be considered, planned for, managed, and monitored (USDA Region 2 1994).

The 1992 Regional Guide contained a definition of biological diversity (See Table 1.2) and goals for its management. A Regional Biological Diversity Assessment (USDA Region 2 1992) was part of this Regional Guide as well as regional goals for biological diversity. Additional direction came from Regional Forester Elizabeth Estill and Research Station Leader Hank Montrey *The Rocky Mountain Station Joint Strategy for Implementing Ecosystem Management* (Estill and Montrey 1992).

As of the writing of this report, there is no requirement for Forests in Region 2 to prepare a general report on biological diversity. However, recent Regional policy has required a biological diversity for Forest Plan revision documents (Hemstrom and Mullen 1993). These discussions are to include coarse filter, fine filter, and the range of natural variablity.

A discussion of biological diversity is being prepared for the Draft Environmental Impact Statement (DEIS) for the Routt portion of the Medicine Bow-Routt National Forest. There is also a document on the Range of Natural Variablity for the Routt NF (Neelan 1994). The Arapaho-Roosevelt NF contracted for a literature review of RNV with Colorado State University (Covich et al. 1994). The Arapaho-Roosevelt NF also has a draft Ecosystem Management Strategy (Brockway et al. 1994) and draft Standards and Guidelines for biodiversity. The Black Hills NF Revision effort also addressed these topics. A biodiversity assessment for the Rio Grande NF is included in the DEIS released in August 1995.

Forest Policy

At the Forest level, the Medicine Bow National Forest published *A Direction for the '90s*, under the adminstration of Gary Heath. This document contained goals for natural resource conservation, sustainability, and recognition of public concerns.

Other Policy Discussions

The underpinnings of philosophical and ethical considerations for the appropriate role of federal agencies in the conservation of native species and ecosystems are found throughout biological literature of the 20th century and through the writings and actions of conservation groups. Some examples: Shelford 1933; Wright and Thompson 1935; Leopold 1949; Caldwell 1970; Wilcove et al. 1986; Clark and Zaunbrecher 1987; Grumbine 1988; Agee and Johnson 1988; Keiter 1989; Wilcove 1989; Wilcove et al. 1989.

A National Forum on Biological Diversity was sponsored by the National Academy of Sciences and the Smithsonian Institution. A Congressional Office of Technology Report (OTA 1987) recommeded three approaches to Congress to conserve biological diversity within the United States:

1. a National Biological Diversity Policy Act to provide guidance
2. a National Conservation Strategy
3. amending authorization for Federal agencies to redirect policies, consolidate conservation efforts and provide criteria for conflict resolution (Shen 1987)

Several conferences concerning biological diversity have been held (Biodiversity in the Rocky Mountains, March 12-15, 1991, Colorado State University; Rocky Mountain New Perspectives, July 8-10, 1991, Denver, CO).

There has been lively discussion of policy for managing biological diversity and ecological integrity on public lands. See references in the following sections.

PRECEDENTS

Article III of the Constitution (Judicial Branch) authorizes the courts to interpret laws. Court decisions set precedents which can affect subsequent official and unofficial policies affecting management of biological diversity and biological integrity.

Precedents for treatment of biological diversity and biological integrity include:

1. setting goals for conservation of biological diversity
2. describing biological diversity
3. assessing the condition of biological diversity and ecological integrity
4. implementing management practices which conserve native species and habitats and contribute to sustainable ecosystems
5. monitoring biological diversity

Biological diversity and ecological integrity issues are often the subject of litigation. In a review of biological diversity issues in Forest Plan appeals (Crow and Kapaldo, 1988) it was noted that most appeals fall into one of five categories:

1. monitoring diversity
2. assessing diversity
3. managing species diversity
4. managing genetic diversity
5. managing ecosystem diversity.

Scale, fragmentation, old growth, reserves and roadless areas, connectivity, dispersal of genes and species, fire interactions with landscapes, and riparian area condition and integrity were often specific issues.

In 1992, a suit brought by three botanists from the University of Wisconsin claimed the Nicolet and Chequamegon National Forests Plan Revisions ignored relevant scientific data existing for at least 20 years and the new Forest Plans were based on inadequate understanding of ecosystems (Mlot 1992). In March, 1994, Judge John W. Reynolds denied the motion and upheld the Forest Service on the grounds that the Chequamegon and Nicolet Forests had followed appropriate procedures, but made clear that recent and relevant information was to be used in the future.

In December, 1994, Judge William Dwyer upheld the President's Northwest Forest Plan, Option 9 in FEMAT (Seattle Audubon Socienty vs Lyons 1994). This decision has far-reaching implications in the area of court actions and suits regarding biological diversity, the used of expert opinion, and the recognition of the quality and quantity of available data.

BIOLOGICAL DIVERSITY AND ECOSYSTEM MANAGEMENT

Biological diversity is not the same as Ecosystem Management. Biological diversity includes descriptions of the composition, structure, processes, and

functions of ecosystems. This includes kinds, amounts and spatial arrangements of living organisms, communities and ecological processes in an area. It includes describing these at different scales of space and in different periods of time to gain an historical perspective. Ecological integrity, the recognition of native species in comparision to introduced (exotic) species, is evaluated. Declining or increasing species and ecosystems are identified. Patterns and processes of change are discussed and related to the past and present. Inference is made as to the future condition of populations of species and changes in ecosystems.

Ecosystem Management is the result of a decision making process which takes information about biological diversity and ecological integrity as one set of considerations along with human social needs, economics, and political realities. The decisions made by the Forest Service and other Federal Land Management Agencies using the paradigm of Ecosystem Management are manifested in Forest Plans and projects implemented by the National Forest Supervisor's Office, Forest Service District, or other agency levels. Knowledge of past and present biological diversity characteristics is a key element in the planning, descision making and implementation processes now under the umbrella of Ecosystem Management (Franklin 1993). A comprehensive discussion of the ecological basis for ecosystem management is in Kaufmann et al. 1994.

The importance of recognizing, understanding, and managing for biological diversity and ecological integrity on a variety of scales is an important component of the Ecosystem Management intiative in the Forest Service (Bengston 1992; Quigley and McDonald 1993; Grumbine 1994). Perpetuation of biological diversity at all scales is a critical element in attaining the goal to sustain diverse and resilient ecosystems with a desired mix of biological communities (Estill and Montrey 1992).

Understanding biological diversity at a variety of space and time scales was a keystone of the FEMAT Report. This is an example of Ecosystem Management, where possible solutions to the needs of people, the perpetuation of ancient forest ecosystems, and the legal mandate to maintain viable populations of native species were important issues considered in designing a plan of action.

Biological diversity and ecological integrity are not simple concepts which can be applied in a general sense to ecosystems. Rather, they are a suite of features of composition, structure, processes, and functions of ecosystems whose properties differ by scale. They are also interactive—the small scale structures, processes, and functions affect the larger scales and vice versa. Biological diversity is a dynamic property of landscapes—change over time is to be expected.

Many aspects of both biological diversity and ecosystem integrity are directly and indirectly affected by land management practices. By law and regulation, the

Forest Service is directed to develop management prescriptions which "where appropriate and to the extent practicable shall preserve and enhance the diversity of plant and animal communities... so that it is at least as great as that which would be expected in a natural forest" (36 CFR 219.28). The overall concept with regard to biological diversity may be interpreted as management of multiple uses within the range of natural variability of ecosystems to permit, as much as possible, the maintainence of natural biological diversity to minimize impacts on ecosystems.

Often the value placed on particular kinds of biological diversity or ecological integrity is a function of management goals. Different species may have different values for different reasons when considered from a management viewpoint. In addition to the values placed on species from a management perspective there is also the viewpoint, held by some, that all species should have value and should have a right to exist, regardless of the goals and uses that humans make of them or their habitat (Sample 1991).

A major goal for ecosystem management is to maintain viable populations of species in the landscape in a way that perpetuates the structure, processes, and functions of ecosystems at all scales. Thus, management decisions must be evaulated in the context of their direct, indirect, and cumulative effects on local populations of species as well as effects at larger scales (watersheds and regional scales which are part of the landscape scale concept). The impacts of these effects over time on biological diversity and ecological integrity deserves careful consideration.

BIOLOGICAL DIVERSITY, CONSERVATION BIOLOGY, AND THE SCIENTIFIC COMMUNITY

The rapid loss of species and ecosystems on a worldwide scale, especially in the tropics, has been a strong force in the development of the discipline of Conservation Biology (Wilson 1985; Williams 1991). Conservation Biology is an applied science with roots in traditional ecology, wildlife biology, landscape ecology and other disciplines. Journals such as *Conservation Biology*, *Ecological Applications*, and *Land and Water Conservation* contain much of the relevant literature on biological diversity. Scientific journals such as *Bioscience*, *Ecology*, *The Forestry Chronicle*, *Fisheries*, and others are also important sources of information on biological diversity. The American Academy of Sciences (AAS) and the Society of American Foresters (SAF), as well as traditional conservation groups such as the Isaac Walton League and the Audubon Society, have all offered ideas on reasons and strategies to conserve biological diversity.

The literature on this subject is extensive, so only a few highlights will be discussed here. Some leading spokesmen in the field of Conservation Biology include Dan Botkin 1990; Reed Noss 1991; Edward Grumbine 1992; Michael Soule 1991b; Alan Cooperrider 1991; Larry Harris 1984; and David Wilcove 1989. In recent years, many of the ideas and principles of Conservation Biology (island biogeography, corridors and reserves, restoration activities, core areas, population demographics) have been studied by researchers in disciplines ranging from genetics and population biology to landscape ecology. Many of these ideas are being endorsed and incorporated into land management plans and projects at state and federal levels nationwide (Soule' 1985; Noss and Harris 1986; Simberloff 1988; Murphy 1990).

The discipline of Landscape Ecology has also made recent major contributions to understanding and interpreting biological diversity (Pickett and White 1985; Forman and Godron 1986; Turner 1987; Urban et al. 1987; Zonneveld and Forman 1990). A research initiative to support biosphere sustainabiity was endorsed by the Ecological Society of America (Lubchenco et al. 1991).

Other private and scientific organizations are also contributing information and leadership to the management of biodiversity. Partnerships between The Nature Conservancy (an advocate of conservation of native species and habitats) and the Forest Service have become common (Topik 1991).

CONSERVATION OF BIOLOGICAL DIVERSITY AND ECOLOGICAL INTEGRITY

Reasons to conserve and perpetuate biological diversity and ecological integrity generally can be expressed by three general categories:

1. direct benefits to humans (sources of medicines, new genes to improve domestic varieties of plants or animals, recreation, and spiritual well-being)
2. indirect benefits to humans by preserving processes such as soil formation, water purification, atmospheric purification and other ecosystem level maintenence services
3. ethics and stewardship (the belief that allowing natural systems to structure themselves and function with a minimum of human interference is the right thing to do)

(Samson and Knopf 1982: Noss 1989; Laidlaw 1991; Pister 1992; Cairns and Lackey 1992; Burton et al. 1992.)

Holmes Rolston, III (1986), a noted environmental philosopher at Colorado State University, points out that while humans have the powerful ability to change the natural order, they are also equipped with a conscience, not given to non-human creatures. With this conscience, humans must wisely direct and balance resource budgets. These budgets include the business resource as well as the natural resource. (Rolston 1986 pp. 164-175).

Strategies to conserve biological diversity range from extreme changes to the human systems in favor of restoring previous diversity (Mann and Plummer, 1993; Noss, 1993) to ways in which state and federal agencies can work together within existing legal, social and economic frameworks (Noss 1983; Scott et al. 1988; Waller 1988; Soule 1991a; Burton et al. 1992; Williams and Rinne 1992; Knight 1992; Noss 1990; Noss 1992; and Angermeier and Karr 1994).

Elements of these strategies include: addressing biological diversity at large scales which transcend managerial and political boundaries (GAP analysis approach); conservation of genetic diversity by a combination of captive breeding and provision of connectivity among habitats for gene flow; retention of biotic integrity (promoting conservation of native species and habitat); minimizing habitat fragmentation by retaining large patches of land for native ecosystems, and connectivity among them; restoring degraded habitats and depleted populations; identifying "keystone" species and protecting populations of threatened, endangered and sensitive species; and managing at landscape scales; managing to retain processes which sustain ecosystems.

ADDITIONAL ANALYSES NEEDED

There are data limitations for most topics addressed in this report. Further analysis will be needed in certain areas, specifically for species-habitat relationships and smaller scale evaluations of terrestrial biological diversity and ecological integrity of watersheds. This report was written in advance of other analyses for the Forest Plan Revision Process, so it does not represent a fully integrated view because information from other areas (for example recreation, timber production, road status) was not available.

LITERATURE CITED

Angermeier, P.L.; Karr, J.R. 1994. Biological integrity versus biological diversity as policy directives. Bioscience 44(10): 690-697.

Bartlett, E.T.; Jones, J.R. (eds). Rocky Mountain New Perspectives: Proceedings of a Regional Workshop USDA Forest Service. GTR RM-220 Fort Collins, CO.

Bengston, D. N. 1992. Changing forest values and ecosystem management. Society and Natural Resources 7: 515-533.

Blockstein, D.E. 1990. Toward a federal plan for biological diversity. Journal of Forestry 88(3): 15-19.

Botkin, D.B. 1990. Discordant harmonies: a new ecology for the twenty-first century. Oxford University Press, N.Y.

Boyce, S.G. 1981. Biological diversity and its use in silviculture. IN: Proceedings of the National Silviculture workshop, Roanoke, VA July 15, 1981. Published by USDA Forest Service, Division of Timber Management, Washington, D.C.

Brockway, D.B.; Sargent, H; Anderson, K.; Gleason,, P.; Peterson,R; Schmidt, D; Parmenter, B. 1994. A strategy for planning and implementation of Ecosystem Management (Final Draft Oct. 17, 1994) Arapaho-Roosevelt National Forest Fort Collins, CO.

Burton, P.J.; Balisky, A.C.; Coward, J.P; Cumming, S.G.; Kneeshaw, D.D. 1992. The value of managing for biodiversity. The Forestry Chronicle 68(2): 225-237.

Cairns, M.A.; Lackey, R.T. 1992. Biodiversity and the management of natural resources: the issues. Fisheries 17(3): 6-10.

Caldwell, L. 1970. The ecosystem as a criterion for public land policy. Natural Resources Journal 10(2): 203-221.

CEQ (Council on Environmental Quality). 1995. A national framework for ecological assessments. (draft) October 16, 1995. Council on Environmental Quality. Washington, D.C.

Clark, T.W.; Zaunbrecher, D. 1987. The Greater Yellowstone Ecosystem: The ecosystem concept in natural resource policy and management. Renewable Resources Journal (summer): 8-16.

Congressional Research Service. 1992. Multiple use and sustained yield; changing philosophies for federal land managers. Proceedings and summary of a workshop for the Committee and Interior and Insular Affairs U.S. House of Representatives March 5 and 6, 1992. Washington, D.C.

Cooperrider, A. 1991. Conservation of biodiversity on western rangelands. IN: Landscape Linkages and Biodiversity. Hudson,W. (ed). Island Press, Washington, D.C. pages 40-53.

Covich, A., Rudman, B.; Smith,S; Kennedy, P.; Cooper, D.; Fausch, K; Wilson, K. 1994. Literature review on the range of natural variation in the Colorado Front Range and associated grasslands. Prepared for the Arapaho-Roosevelt National Forest Fort Collins, CO.

Crow, T.R. 1991. Landscape ecology: the big picture approach to resource management. IN: Decker, D.J. et al. (eds.) Challenges in the Conservation of Biological Resources: A Practioners Guide Boulder, CO: Westview Press: 55-65.

Crow, T.; Kapaldo, D. 1988. A summary of forest plan appeal issues related to biological diversity. USDA Forest Service Working Paper for Forest Service Biodiversity Steering Committee Washington, D.C.

Estill, E., Montrey, H. 1992. The Rocky Mountain Station joint strategy for implementing Ecosystem Management. Letter to the Chief. Sept. 3, 1992. Denver, CO.

Federal Register. Thursday Sept. 30, 1982. Volume 47 (190): 43051-43052

FEMAT. 1993. Forest ecosystem management: an ecological, economic and social assessment. Report of the Forest Ecosystem Management Assessment Team. USDA Forest Service and USDA Bureau of Land Management.

Forman, R.T.T.; Godron, M. 1986. Landscape ecology. Wiley New York.

Franklin, J.F. 1992a. Forest stewardship in an ecological age. SUNY College of Environmental Science and Forestry Miscellaneous Publication No. 27 Syracuse, N.Y.

Franklin, J.F. 1992b. Scientific basis for new perspectives in forests and streams. IN: Naiman, R.J. (ed) Watershed Management: Balancing Sustainability and Environmental Change. Springer-Verlag, N.Y.

Franklin, J.F. 1993. The fundamentals of ecosystem management with applications in the Pacific Northwest. IB: Aplet, G.H., Johnson, N., Olson, J.T. and V.A. Sample (eds). Defining Sustainable Forestry Island Press Washington, D.C. pages 127-145.

Greater Yellowstone Coordinating Committee. 1987. The Greater Yellowstone Area: An aggregation of national park and national forest management. Greater Yellowstone Coordinating Committee.

Grumbine, R.E. 1988. How to save the national parks and national forests. Forest Watch 9(6): 21-27.

Grumbine, R.E. 1992. Ghost bears: exploring the biodiversity crisis. Island Press Washington, D.C.

Grumbine, R.E. 1994. What is ecosystem management? Conservation Biology 8(1): 27-38.

Harris, L.D. 1984. The fragmented forest. University of Chicago Press. Chicago, IL.

Hayward, G.D.; Verner, J. 1994. Flammulated, boreal and great gray owls in the United States: A Technical Conservation Assessment. USDA Forest Service General Techinical Report RM-253.

Healy, M. (ed.) 1992. Restoring ecosystems in the Blue Mountains. A report to the Regional Forester and Forest Supervisors of the Blue Mountain Forests. USDA Forest Service Report - Pacific Northwest Region.

Hemstrom, M.; Mullen, L. 1993. Draft biological diversity assessment protocol. Region 2 USDA Forest Service, Lakewood, CO.

Interagency Protocol Team. October, 1994. Draft national framework for integrated ecological assessments. Washington, D.C.

Kaufmann, M.R.; Graham, R.T.; Boyce, D.A. Jr.; Moir, W.H.; Perry, L.; Reynolds, R.T.; Bassett, R.L.; Mehlhop, P.; Edminster, C.B.; Block, W.M.; Corn, P.S. 1994. An ecological basis for ecosystem management. USDA Forest Service General Technical Report RM-246. Fort Collins, CO.

Keiter, R.B. 1989. Taking account of the ecosystem in the public domain: Law and ecology in the Greater Yellowstone Region. University of Colorado Law Review 60(4): 933-1007.

Keiter, R.B. 1990. NEPA and the emerging concept of ecosystem management on the public lands. Land and Water Law Review Vol. 25(1): 43-60.

Kessler, W.B.; Salwasser, H.; Cartwright, C.W., Jr.; Caplan, J. 1992. New Perspectives for sustainable natural resources management Ecological Applications 2(3): 221-225.

Kirby, M.; Laner, S. 1989. Analysis of the Chief's decisions on selected appealss. Final Report USDA Forest Service PSW Station Berkeley, CA.

Klamath National Forest, USDA Forest Service. 1993. DEIS - Forest Plan Revision Biological Diversity Report. Eureka, CA.

Knight, D.H. 1992. Landscape ecology and national forest management. Ecosystem Management Workshop Jan. 7-9, 1992 Denver, CO.

Laidlaw, R. 1991. A Native American concept of land ethics. Trends in Ecology and Evolution 28(3): 12-14.

Langner, L.L.; Flather, C.H. 1994. Biological diversity: status and trends in the United States. USDA Forest Service General Technical Report RM-244. Fort Collins, CO.

Leonard, G.M. 1990. The land manager's need for science. 19th International Union of Forestry Research Organizations (IUFRO) World Congress Montreal, Canada August 8, 1990.

Leopold, A. 1949. A sand county almanac. Oxford University Press, N.Y.

Lubchenco, J.; Olson, A.; Brunaker, L.B.; Carpenter, S.R.; Holland, M.M.; Hunbell; S.P.; Levin, S.A.; MacMahon, J.A.; Matson, P.A.; Mellillo, J.M.; Mooney, H.A.; Peterson, C.H.; Pulliam, H.R.; Real, L.A.; Regal, P.J; Risser; P.G. 1991. The sustainable biosphere initiative: An ecological research agenda. Ecology 72(2): 371-412.

Lyons, J. 1993. Statement concerning the Adminstration's proposed northwest timber policy. U.S. House of Representatives August 3, 1993. Washington, D.C.

Mann, C.C.; Plummer, M.L. The high cost of biodiversity. (Wildlands project) Science 260: 1868-1871).

McMinn, J.W. 1991. Biological diversity research: an analysis. USDA Forest Service GTR SE-71. Asheville, N.C.

Mlot, C. 1992. Botanists sue Forest Service to preserve biodiversity. Science 257: 1618-1619.

Moir, W. 1995. personal communication.

Morgan, P.; Aplet, G.; Haufler, J.B.; Humphries, H.C.; Moore, M.M.; Wilson, W.D. 1994. Historical range of variability: a useful tool for evaluating ecosystem change. The Journal of Sustainable Forestry 2(1/2): 87-111.

Mullen, L. 1994. Working outline for biodiversity assessment on the Rio Grande National Forest. October, 1994. Denver, CO.

Murphy, D.D. 1990. Conservation biology and the scientific method. Conservation Biology 4(2): 203-204.

Neelan, C. 1994. Determining the range of natural variability (Routt National Forest). Steamboat Springs, CO.

Noss, R. F. 1983. A regional landscape approach to maintain diversity. Bioscience 33(11): 700-706.

Noss, R. F. 1989. Who will speak for biodiversity? Conservation Biology 3(2): 202-203.

Noss, R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4(4): 355-364.

Noss, R.F. 1991. Landscape connectivity: different functions at different scales. IN: Landscape Linkages and Biodiversity Hudson, W. (ed). Island Press, Washington, D.C.: 27-39.

Noss, R.F. 1992. Guidelines for biodiversity management. Adapted by Defenders of Wildlife from: Interpreting biodiversity by Reed Noss IN: Nature Watch: A Resource for enhancing Wildlife Viewing Areas Falcon Press Helena, MT.

Noss, R.F. 1993. The Wildlands Project land conservation strategy. Green Disk paperless Environmental Journal Vol. 2(5) Washington, D.C.

Noss, R.F.; Harris, L.D. 1986. Nodes, networks and MUS's: preserving diversity at all scales. Environmental Management 10(3): 299-309.

OTA (Office of Techological Assessment). 1987. Technologies to maintain biological diversity. Report to Congress. U. S. Government Printing Office 052-003-01057-7.

Overbay, J.C. 1992. A bias toward diversity: The meaning of ecosystem management on the National Forests. Forest Watch 13(3): 19-23.

Pickett, S.T.A; White, P.S. 1985. The ecology of natural disturbance and patch dynamics. Academic Press Orlando, FL.

Pister, E.P. 1992. Ethical considerations in conservation of biodiversity. Trans. 57th N.A. Wildlife and Natural Resources Conference: 355-365.

Quigley, T.M.; McDonald, S.E. 1993. Ecosystem management in the Forest Service: Linkage to endangered species management Endangered Species UPDATE 10(3/4): 30-33.

Robertson, 1992. Ecosystem management of the National Forests and grasslands. Memo to Regional foresters and Station Directors, USDA Forest Service June 4, 1992.

Rolston, H., III. 1986. Philosophy gone wild - essays in environmental ethics. Prometheus Books Buffalo, N.Y.

Ruggiero, L.; Aubry, K.B.; Buskirk, S.W.; Lyon, L.J.; Zielinski, W.J. 1994. The scientific basis for conserving forest carnivores: american marten, fisher, lynx and wolverine in the Western United States. USDA Forest Service General Technical Report RM-254. Fort Collins, CO.

Runte, A. 1991. Public lands, public heritage - the national forest idea. Roberts Rinehart Publishers Niwot, CO.

Salwasser, H. 1987. Editorial for "Conservation Biology" on strategies to conserve biological diversity. Conservation Biology 1(4): 275-277.

Salwasser, H. (winter) 1991a. New perspectives in managing the national forests and grasslands. Environmental Planning Quarterly 8)3): 8-19.

Salwasser, H. 1991b. Roles for land and resource managers in conserving biological diversity, IN: Challenges in the Conservation of Biological Resources: A Practitioners Guide Decker, D.J. et al. (eds). Westview Press San Francisco, CA pp. 11-28.

Salwasser, H.; MacCleery, D.W.; Snellgrove, T.A. 1993. An ecosystem perspective on sustainable forestry and new directions for the U.S. National Forest System. IN: Aplet, G.H., Johnson, N., Olson, J.I. and V.A. Sample (eds.) Defining Sustainable Forestry Island Press, Washington, D.C. pages 44-89.

Sample, V.A. 1991. Land stewardship in the next era of conservation. Gray Towers Press Milford, PA.

Sampson, F.B.; Knopf, F.L. 1982. In search of a diversity ethic for wildlife management. 47th N.A. Wildlife Conference: 421-431.

Science Integration Team, Eastside Ecosystem Management Projected. 1994. Scientific Framework for Ecosystem Management in the Interior Columbia River Basin. Working Draft- Version 2 Walla Walla, WA.

Scott, J.M.; Csuti, B.; Smith, K.; Estes, J.E.; Caicco, S. 1988. Beyond endangered species: An integrated conservation strategy for the preservation of biological diversity. Endangered Species UPDATE 5(1): 43-48.

Seattle Audubon Society, et al. vs James Lyons et al. Dec. 21, 1994 U.S. District Court Decision. Judge William L. Dwyer. Seattle, WA.

Shelford, V.E. 1933. Ecological Society of America: A nature sanctuary plan unanimously adopted, 28 December, 1932. Ecology 14(2): 240-245.

Shen, S. 1987. Biological diversity and public policy. 1987. Bioscience 37(10): 709-712.

Simberloff, D. 1988. The contribution of population and community biology to conservation science. Annual Review of Ecology and Systematics 19: 473-511.

Soule', M.E. 1985. What is conservation biology? Bioscience 35(11): 727-734.

Soule', M. E. 1991a. Conservation: tactics for a constant crisis. Science 253: 744-750.

Soule', M. E. 1991b. Conservation corridors: countering habitat fragmentation: Theory and Strategy. IN: Landscape Linkages and Biodiversity Hudson,W. (ed). Island Press, Washington, D.C. pages 91-104.

Swanson, F.J.; Franklin, J.F. 1992. New forestry principles from ecosystem analysis of Pacific Northwest Forests. Ecological Applications 2(3): 262-274.

Thomas, J.W. 1985. Towards the managed forest: going places that we've never been. The Forestry Chronicle April, 1985 pp. 168-170.

Thomas, J.W. 1994. Statement of Dr. Jack Ward Thomas, Chief, USFS, USDA to theCommittee on Natural Resources, U. S. House of Representatives Feb. 3, 1994 concerning "New directions for the Forest Service".

Thomas, J.W. et al. 1991. A conservation strategy for the northern spotted owl: a report of the Interagency Scientific Committee to address the conservation of the northern spotted owl. Portland, OR: USDA Forest Service, Bureau of Land Management, US Fish and Wildlife Service and National Park Service.

Titus, T.R. 1992. Biodiversity: The need for a national policy. Fisheries: 17(3): 31-34.

Topik, C. 1991. Forest Service and the Nature Conservancy join forces to conserve biological diversity. Endangered Species Technical Bulletin 16(4): 8.

Turner, M.G.(ed) 1987. Landscape heterogeneity and disturbance. Springer-Verlag, NY.

Urban D.L.; O'Neill, R.V.; Shugart, H.H., Jr. 1987. Landscape ecology: a hierarchical perspective can help scientists understand spatial pattern. Bioscience 37(2): 119-127.

USDA. 1990. RPA. The Forest Service program for forest and rangeland resources: A Long-term Strategic plan. Washington, D.C..

USDA. 1991. Conserving our heritage: America's biodiversity. USDA Forest Service. Washington, D.C..

USDA. 1993. The principal laws relating to Forest Service Activities. 1993 Version. U.S.Government Printing Office, Washington, D.C..

USDA. 1995. Guide to Forest Service Directives. Directives and Regulations Branch, Information Systems and Technology Staff, Washington, D.C.

USDA, Region 2. 1992. Biological diversity assessment. Lakewood, CO.

USDA, Region 2. 1994. Desk Guide for Plan Revisions April, 1994. Lakewood, CO.

USDA. Beaverhead National Forest. 1991. Trail Creek Supplemental Information Report USDA Forest Service Northern Region Dillon, MT.

USDA. Medicine Bow National Forest. 1992. FEIS - Oil and Gas Leasing Environmental Impact Statement. Laramie, WY.

USDA - Medicine Bow-Routt National Forest. 1995. Routt National Forest Draft Environmental Impact Statement - Land and Resource Management Plan Revision. In Progress.

USDI. 1993. Ecosystem Management in the BLM: A process to promote biological diversity and sustainable development. Draft Concept Paper. Washington, D.C..

USDI, USDA. 1992. America's biodiversity strategy: actions to conserve species and Habitats Preprint Washington, D.C.

Virginia Department of Conservation and Recreation Division of Natural Heritage. 1991. Biological Diversity Protection on the George Washington National Forest. Natural Heritage Technical Report 91-1. Department of Conservation and Recreation Richmond, VA.

von Ahlefeldt, J.; Byer, T.; Edwards, M.; Speas, C. 1992. Biological Diversity Technical Report for the Thunder Basin National Grassland USDA Forest Service Medicine Bow National Forest Laramie, WY.

Waller, D.M. 1988. Sharing responsbility for conserving diversity: The complementary roles of conservation biologists and public land agencies Conservation Biology 2(4):398-401.

Wilcove, D.S. 1989. Protecting biodiversity in multiple-use lands: Lessons from the U.S. Forest Service Trends in Ecology and Evolution 4(12): 385-388.

Wilcove, D.S.; McLellan, C.; Dobson, A.P. 1986. Habitat fragmentation in the temperate zone. Pages 237-256 IN: M.E. Soule' (ed): Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates Sunderland, MS.

Williams, J.T. 1991. International aspects of biodiversity. The Forestry Chronicle 68(4):454-458.

Williams, J.E.; Rinne, J.N. 1992. Biodiversity management on multiple-use federal lands: An opportunity whose time has come. Fisheries 17(3): 4-5.

Wilson, E.O. 1985. The biological diversity crisis. Bioscience 35(11): 700-705.

Wright, G.M.; Thompson, B. 1935. Fauna of the National Parks of the United States. USDI Washington, D.C..

Zonneveld, I.S. and R.T.T. Forman (eds.). 1990. Changing landscapes: An ecological perspective. Springer - Verlag, New York.

CHAPTER 2

BIOLOGICAL DIVERSITY AND ECOSYSTEM SCALES, COMPOSITION, STRUCTURES, FUNCTIONS AND PROCESSES

FOREST SERVICE DIRECTION

The Rocky Mountain Regional Guide provides procedural direction for National Forest Plans in Region 2. The *Biodiversity Assessment* for the *Rocky Mountain Regional Guide* recognized an organizational hierarchy for biological diversity based on the community, species and genetic scales. This provides a framework of interrelated scales of regional, landscape, watershed and local sites for ecosystem management (USDA Region 2 1992).

In this report, composition, structure, process and function attributes are discussed for the landscape and community scales (coarse filter scale) and the species and genetic scales (fine filter scales). Structure is am emergent property of composition and functions are emergent properties of processes. The following discussion and Table 2.1 summarize some features of these attributes at each scale.

There are some differences between the Coarse Filter Strategy formulated by spokesmen for the discipline of Conservation Biology and the Region 2 Coarse Filter Analysis required for Forest Plan Revision. The Coarse-Filter Strategy is a Conservation Biology strategy for maintaining and managing biological diversity (Hunter 1991; Wilcove 1989). Articulation of landscape and community level land units is one component of devloping the conservation strategy.

The product of the Region 2 Coarse Filter Analysis, is a map from Landsat imagery showing various cover types in the Landsat image, and the position of National Forest Lands in this context. Description of this level of biological diversity is used to place the National Forest in a larger ecosystem context. The Coarse-Filter Analysis from Landsat was not completed at the time this report was written. For Coarse Filter Scale considerations In this report, maps and tables prepared from the RIS database, depicting patterns at the landscape level are used.

Table 2.1 Hierarchy for description of biological diversity

LEVEL	ATTRIBUTE	SAMPLE DESCRIPTORS
LANDSCAPE		
	Composition & Structure	matrix; patch size, type and arrangement; corridors, nodes; heterogeneity; connectivity; fragmentation characteristics
	Process & Function	climate change; geomorphic processes; patch transitions; disturbance intensity, frequency, areal extent; patch persistence biomass production and nutrient cycles; energy flow
COMMUNITY		
	Composition & Structure	species composition; physical community structure; guilds; life form composition; physiognomic characteristics
	Process & Function	succession; herbivory; disturbance; biomass production and nutrient cycles; energy flow
SPECIES		
	Composition & Structure	species richness and evenness
	Process & Function	competition; population dynamics; dispersal; biomass production; nutrient cycles; energy flow
GENETIC		
	Composition & Structure	gene pool characteristics
	Process & Function	mutation; evolution; speciation; isolation gene; flow

The logical basis for a Coarse Filter Strategy is that maintenence of biological diversity at larger landscape and community levels should protect viable populations of most species. For the remaining species (those that "fall through" the pores of a coarse filter), a series of Fine Filters are needed. Fine filters are individually tailored conservation plans for those species requiring them. The federal endangered species program exemplifies the Fine Filter Approach (Hunter 1991).

Advantages of the Coarse Filter Strategy over the Fine Filter Strategy are cost and efficiency. It is more cost-effective to manage ecosystem units than to manage a myriad of endangered species scattered over the landscape. The Coarse Filter Strategy maintains the integrity of whole ecological systems, thereby both sustaining the ecological and evolutionary context in which organisms exist and protecting populations of species (Hunter 1991). The Coarse Filter strategy for maintaining biological diversity applies to landscape and community scales; the Fine-Filter strategy applies to species and genetic scales. Part of the Coarse-Filter Approach is the analysis of pattern within the landscape, including size and shape of patches, amount of edge, age structure and other measureable landscape attributes.

The Region 2 Fine Filter Analysis consists of gathering information on existing and historical occurrence of Federally Threatened and Endangered Species and Candidate Species and Region 2 Sensitive Species (TECS species) at the level of the ECOMAP Ecoregion Section (Bailey et al. 1994). and the National Forest. The Fine Filter Analysis is primarily a compilation of information about TECS specis at a scale larger than the National Forest Administrative Unit. This information is found in this report in Chapters 7,8 and Appendices 4,5,7,8 and 9. Species information is stratified by mountain range and Biodiversity Areas (BDU's) within mountain ranges.

The Range of Natural Variablity will be discussed conceptually in this report as Ranges of Historical Variation, with application to a broad set of scales and topics. For the Landscape Metrics Analysis, means are used as quantitative indicators of historic conditions.

The October, 1995 draft National Framework for Integrated Ecological Assessements also refers to this concept as "Historic Variability" (CEQ 1995). Temporal variablity superimposed on spatial variability shapes not only the observed present pattern of diversity, but is also important as a framework for evolution, thus determining the course of future diversity. The underlying assumption here is that understandng historical variation is essential to understanding natural evolutionary and biogeographic processes which produced native ecosystems (Angermeir and Karr 1992).

ECOLOGICAL THEORY AND BIODIVERSITY

This section provides current information on some aspects of ecological theory which have bearing on biological diversity, ecological integrity and data interpretation.

Ecosystems occur at many scales from the community scale, which might be defined for an area as small as a decaying log, through the level of the large systems which are used to describe the biosphere. An ecosystem is a real time-space object with dimensions of soil and landform, organisms and climate as well as the processes which occur over time to make these into functional wholes (Swanson et al. 1988; Rowe, 1992). The genetic component, while not technically an ecosystem, influences all higher levels to some degree through time because the gene pool of a population is a fundamental unit of evolutionary change.

The genetic component, and the physiological interactions of organisms and environment, are contained within the organisms found in ecosystems. The gene pool is a property of a population, which is an nterbreeding group of individuals. At local scales, populations of organisms occur in groups called communities. Communities, in turn, aggregate into landscapes. Large landscape areas may contain meta-populations. It is convenient to define ecosystems in the context of physical map units at the community and landscape scales.

Fragmentation of ecosystems occurs when the matrix, or most homogeneous portion of the landscape, is divided into patches with different characteristics. Patches may be discrete entities, or they may be formed by the presence of linear features. Fragmentation may occur at a variety of temporal and spatial scales. It may involve a long term change (conversion of forest to cropland) or a short term change (age fragmentation of forests due to disturbances). Either way, fragmentation usually effects on ecosystem structure and function, and may effect population viablity of community members. The scale of fragmentation may be large or small and the cumulative effects may or may not have population viability or ecosystem sustainability ramifications.

Ecosystem fragmentation occurs when portions of a landscape are physically and/or biologically isolated. Isolation may be partial or complete. Biological processes or functions may be impaired. This may occur on a variety of scales and effects can be cumulative in space and time. An example is where connectivity or contiguity in a previously continuous or contiguous ecosystem is disrupted by natural or man-caused disturbance. This could be a forest matrix altered by fire, blowdown or timber harvest or a stream corridor interrupted by dams, road crossings and culverts.

Fragmentation can be described by changes in composition, structure, processes or functions. For uplands, a mature ecosystem which is the matrix at a community or landscape scale may become so perforated by patches, that the original matrix may become patches in a new kind of matrix characterized by earlier seral stages. This involves changes in patch juxtaposition, seral stages and ecological conditions.

For streams, fragmentation can be descibed by changes in water volumes, gradients, sediment loads, bank conditions and other attributes which change as dams are built, valleys flooded, beavers removed, riparian vegetation depleted, sediment loads changed or other defineable species or ecosystem attributes altered.

Fragmentation may also be expressed at the genetic scale as genetic isolation or interference with gene flow. Functinal fragmentation at landscape or community scales can include changes affecting energy and material flows within ecosystems or across ecosystem boundaries (Knopf and Smith 1992).

The maintenence of minimum viable populations is a concern for biological diversity. This is a very difficult concept to address quantitatively because comprehensive studies to determine minimum viable populations have not been done on the Medicine Bow National Forest and the techniques to determine what a minimum viable population is have not been well defined anywhere. A practical alternative is managing for large and well-distributed populations, using a landscape and ecosystem (coarse filter) approach (Probst and Crow 1991).

Much of the biological diversity responsible for ecosystem health and sustainability is "invisible diversity", found in microorganisms or invertebrate species (Probst and Crow 1991). Most biological diversity assessments lack any information concerning these organisms. This report includes rudimentary information on conifer and *Vaccinium* mycorrhizae, and lichens (See Appendices).

The task of identifying functional ecological groups, minimal structure frameworks, animal guilds, keystone species, critical link species and process relationships which support ecosystem sustainability (West 1993) lies largely in the future. The analyses presented in this document should provide a basis for future biological diversity evaluation to understand these factors and apply them to management.

ECOSYSTEM COMPOSITION AND STRUCTURE

The kinds of descriptors and ways of measuring biological diversity and ecological integrity differ depending on the scale being described (Magurran 1988).

The landscape level aggregates communities from a scale withiin small watersheds to regions. At the landscape scale, ecosystem structure and composition is described by characteristics of the matrix, patches, and linkage structure of the landscape under consideration. Various measures of biological diversity this and at smaller scales can be used as conceptual qualitative descriptors (Romme and Knight 1982).

At the community level, biological diversity of ecosystems can be described by evaluating species composition and physical community structure.

At the species level, biological diversity can be described using species richness (kinds of species) or species evenness (distribution of abundance or importance of different species) in the context of communities. Species richness or evenness can be evaluated in the context of the community scale or the landscape scale.

At the genetic scale, the structure and composition of the gene pool, and the presence and variation of configurations of DNA for a species, is the focus of biological diversity. For this report, the only s pecies for which there is specific, quantitiatve genetic information is Colorado River cutthroat trout. Population biology and genetic theory provide a good basis for inference about the relationship of landscape pattern to genetic options.

The 1985 MBNF Forest Plan recognized two other kinds of diversity - vertical diversity and horizontal diversity. Vertical diversity is defined as .." the complexity of the above-ground structure of the vegetation"; and horizontal diversity as .."the number of plant communities or successional stages or both". These concepts are both related to the structure and composition of ecosystems at the species and community levels and have their basis in the CFR Regulations (Section 219). They do not address ecosystem processes or functions, nor do they address vegetation condition.

ECOSYSTEM PROCESSES AND FUNCTIONS

Biological diversity can also be described with reference to the processes within and functions of ecosystems. Ecosystem function is cumulative property of ecosystem processes. Over time both processes and function change in ecosystems.

Processes also cause change in structure and composition of species, communities and landscapes over time. Landscape level disturbance processes can cause changes in patches. Succession of species result in different community types. Populations change at the species level due to disease, natality, and mortality, or as mutation, evolution, and speciation at the genetic level affects survival of individuals and populations. As structure and composition of ecosystems change, functions such as biomass production, dependent on processes such as photosynthesis will also change (Ricklefs 1987; Baskin 1994; Vitousek 1994).

Specific processes which affect landscape structure may include climate change, geomorphic processes, or large scale disturbances such as fire, grazing, or timber harvest. Similar smaller scale disturbances including fire, grazing or timber harvest, succession, and competition among populations are examples of processes affecting the community level.

Processes at the species population level include the dynamics of populations, affected by birth, death, predation, disease, stress and competition among individuals of the same or different species, and dispersal, are keystone processes affecting the presence of species and subsequently the biological diversity characteristics of communities and landscapes (Johnson 1984).

Processes are nested from the genetic to the landscape level and are intricately linked to ecosystem structure. For example, mutations which affect the ability of individuals (and therefore populations) to survive, compete and persist in the landscape, will affect species richness and evenness, and will be measured as changes in community composition and structure at local scales, and as landscape composition and structure changes at larger scales.

Ecosystem functions describe the flow of energy and materials within and between ecosystems at any scale. This may include the exchange and flow of genetic material, physiological exchange of energy and materials between an individual and the environment or the aggregation of these functions expressed as biomass production or large-scale nutrient cycling at the community or landscape level.

Ecosystem functions are dependent on the structure and composition of the ecosystems, and the processes which occur as materials and energy are exchanged. The nature and stability of biological diversity is associated with the integrity of these ecosystem functions. For example, if there are changes in the flow of energy and materials within an ecosystem due to natural disturbances or human-induced change such as introduction of livestock, removal of livestock, predator control, surface mining, road construction, use of fertilizer, herbicides, changes in water flow or water quality, the result will be changes in the composition and structure of the communities and landscape with consequential changes in biological diversity and ecological integrity.

LITERATURE CITED

Angermeir, P.L.; Karr, J.R. 1994. Biological integrity versus biological diversity as policy directives. Bioscience 44(1): 690-697.

Bailey, R.G.; Avers, P.; King, T.; McNab, W.H. 1994. Ecoregions and Subregions of the United States. Map. USFS Washington, D.C.

Baskin, Y. 1994. Ecosystem function of biodiversity. Bioscience 44(10): 657-660.

CEQ (Council on Environmental Quality). 1995. National framework for integrated ecological assessments. October 16, 1995 Draft. Council on Environmental Quality. Washington, D.C.

Hemstrom, M.; Mullen, L. 1993. Draft biological diversity assessment protocol. Region 2 USDA Forest Service Denver, CO.

Hunter, M. 1991. Coping with ignorance: The Coarse-Filter Strategy for maintaining biodiversity. IN: Kohm, K.A. (ed). Balancing on the brink of extinction - the Endangered Species Act and Lessons for the future . Island Press Washington, D.C..

Johnson, H.B. 1984. Consequences of species introductions and removals on ecosystem function - implications for applied ecology. Proc. VI Int. Symp. Biol. Contr. Weeds August 15-25, 1984. Vancouver, Canada.

Knopf, F.L.; Smith, M.H. 1992. Biological diversity in wildlife management. Wildlife Management Institute Washington, D.C.

Magurran, F.A. 1988. Ecological diversity and and its measurement. Princeton University Press Princeton, N.J.

Probst, J.R.; Crow, T.R. 1991. Integrating biological diversity and resource management. Journal of Forestry Feb. 1991: 12-17.

Ricklefs, R.E. 1987. Community diversity: relative roles of local and regional processes. Science 235: 167-171.

Romme, W.H.; Knight, D.H. 1982. Landscape diversity: the concept applied to Yellowstone Park. Bioscience 32(8): 64-670.

Rowe, J.S. 1992. Landscape ecology: The study of terrain ecosystems IN: Landscape ecology and management. Moss, M. (ed.) Polyscience Publications, Montreal, Canada.

Swanson, F.J.; Kratz, T.K.; Caine, N.; Woodmansee, R.G. 1988. Landform effects on ecosystem patterns and processes. Bioscience 38(2): 91-98.

USDA Forest Service, Region 2. 1992. Biological diversity assessment. Lakewood, CO.

Vitousek, P.M. 1994. Beyond global warming: Ecology and global change. Ecology 75(7): 1861-1976.

West, N.E. 1993. Biodiversity of rangelands. Journal of Range Management 46: 2-13.

Wilcove, D.S. 1989. Protecting biodiversity in multiple-use lands: Lessons from the U.S. Forest Service. Trends in Ecology and Evolution 4(12): 385-388.

CHAPTER 3

THE GEOGRAPHIC AND CLIMATIC SETTING OF THE MEDICINE BOW NATIONAL FOREST

GEOGRAPHY

MOUNTAIN RANGES

The Medicine Bow National Forest in south-central and southeastern Wyoming positioned at the north end of a large area of uplifted mountains located mainly in Colorado (Figure 3.1). The Administrative area includes four discontiguous mountainous units of about 1,000,000 acres (Figure 3.2). Three of these units are northern extensions of the Colorado Front Range, the fourth unit (Sierra Madre) is an extension of the Park Range.

1. The northern Laramie Mountains (also called the Laramie Peaks) is the northernmost portion of the Front Range.

2. The Sherman Mountains (containing the Pole Mountain Unit of the Laramie Ranger District) are located between Laramie and Cheyenne.

3. The Snowy Range of the Medicine Bow Mountains is a branch of the Front Range. Medicine Bow Peak (12,013 feet), the crowns the Snowy Range and is the highest point on the MBNF. The Medicine Bow Mountains technically extend from Elk Mountain southward through the Rawah Mountains in Colorado to Cameron Pass. The Snowy Range comprises the northern part of the Medicine Bow Mountains within the NFS boundary. In this report "Medicine Bow Mountains" refers to the mountains north of the Wyoming State line. Reference to "Snowy Range North" (SRN) and "Snowy Range South (SRS)" is to the northern and southern portions of the Medicine Bow Mountains in Wyoming. These areas are defined by the divide between French Creek and Mullen Creek on the west side of the Snowy Range, and along the northern boundary of the Douglas Creek watershed on the east side. Sheep Mountain is included with Snowy Range South.

4. The fourth unit is the Sierra Madre Mountains, the northern end of the Park Range which contains the Mount Zirkel Wilderness area in Colorado. The Park Range is separated from the Front Range by Middle Park and North Park. The Brush Creek Hayden District is contiguous with the North Park and Hahn's Peak Districts of the Routt portion of the Medicine Bow-Routt National Forest.

The Forest Administrative boundary within Wyoming, includes essentially all of the forested area in the Sierra Madre Mountains. In the Medicine Bow Mountains, there are forested areas north of the Forest Boundary, including Elk Mountain. The National Forest Administrative Area in the Laramie Mountains and Sherman Hills includes most of the heavily forested land. There are inholdings of private and state land in the Laramie Mountains which contain forested habitats. However most private land is shrubland or grassland in valley bottoms.

LAND CLASSIFICATION

Land classification of the MBNF by Ecological Section and Preliminary Subsections is in Figure 3.3 and Table 3.1 (McNab and Avers 1994). This method of land classification has been developed for large scale land areas in the United States by the ECOMAP team in the Washington Office of the Forest Service in cooperation with other agencies (Bailey et al. 1994). The four largest categories are Domain, Division, Province and Section. Preliminary Subsections developed in cooperation with the Regional Office, are described in Appendix 18.

Most of the Medicine Bow National Forest is in Section M331I (Northern Parks and Ranges) but portions of the Central Basin and Hills Section are found along the edges of the Medicine Bow Mountains, Sierra Madre Mountains and Sherman Mountains.

Identification of landtype associations (LTAs) and landtypes (LTs) is in early stages. In 1988, Marston and Clarendon prepared a land systems inventory of the Medicine Bow and Sierra Madre Mountains. They recommended a scheme of 26 landtype associations based on combinations of map units representing geology, landforms, vegetation, soils and lithomorphic units. Their landtype associations were labed with broad scale vegetation unit, landform and geologic substrate descriptors. Examples are: Bare crystalline high mountains; Alpine crystalline high hills; Mixed forest sedimentary hills; Coniferous crystalline canyons.

Using this system, eleven landtype associations were defined for the Sierra Madre. Three in the southwestern portion (Battle Creek and Little Snake River watersheds) are not found in the Medicine Bow Mountains. The Medicine Bow Mountains have 23 of the 26 landtype associations, according to this classification. There have not been any comparable efforts to classify the Sherman Mountains or the Laramie Mountains.

Personnel working on the Integrated Resources Inventory (IRI) effort in Region 2 have prepared a Common Land Unit Chapter (IRI 1995) which provides terms and descriptions for describing physical elements of landscapes. In 1993, the San Juan National Forest devised an approach to defining landtype associations in

conjunction with the Integrated Resources Inventory (IRI) using a matrix of landform and elevation/climate zones as key elements Table 3.2). This method produces 20 landtype associations. This method of classifying landtype associations is applied to the MBNF as the lists of numbers within each Preliminary Subsection in Table 3.3.

Recently, Reiners and Thurston (1995) delineated landtype associations within the Great Plains physiographic province of Wyoming, north and east of the Laramie Mountains by contract with the Bureau of Land Management. They used remote sensing data to assist with LTA delineation. The nomenclature system they used is different from that presently used by the Forest Service.

Regional Forest Service standards for mapping Landtype Associations are being developed by a Regional Soils Group Taskforce (USDA Forest Service 1995). Draft or interim soil surveys have been completed for the Sherman Hills (Edwards 1989), for the Laramie Mountains (Edwards 1992). and the Sierra Madre and Medicine Bow Mountains (Bauer et al. 1989).

GEOLOGY AND GEOMORPHOLOGY

Many excellent publications by the Wyoming Geological Survey, University of Wyoming Geology staff, and others, are available on the Sierra Madre and Medicine Bow Mountains (Houston 1968; Houston and Ebbett 1977; Oviatt 1977; Houston and Karlstrom 1992; Houston et al. 1992; Knight 1990; Hausel 1993). Industry interest in diamondiferous kimberlites and a large, low-grade gold-copper deposit east of Curt Gowdy State Park have prompted additonal studies of the Sherman and Laramie Mountains (Hausel personal communication). A Geologic Map of Wyoming was prepared by the the Wyoming Geological Survey (Love and Christiansen 1985). A partial bibliography of geologic studies on the MBNF is in Appendix 1.

MOUNTAIN RANGES

Schematic geology maps of the MBNF are presented in Figure 3.4 (a,b). During the Miocene Period Precambrian rocks were uplifted through late Paleozoic and Cretaceous rocks composed primarily of sandstone, limestones and conglomerates. Volcanic intrusive rocks are found in the southwestern Cheyenne Mountains. For a detailed discussion see Hausel 1993.

Table 3.1 **Classification of the Medicine Bow National Forest - National Hierarchy of Ecological Units.**

Category	Map Code
Dry Domain	**(300)**
Temperate Steppe Regime Mountains Division	**(M330)**
-Southern Rocky Mountain Steppe - Open Woodland - Coniferous Forest - Alpine Meadow Province	(M331)
-Northern Parks and Ranges Section	(M331I)
-Intermountain Semi-desert Province	(342)
-Central Basin and Hills Section	(342F)

Table 3.2 **Landtype Association (LTA) Categories using a landform/ elevation matrix (IRI method).** See Table 3.3 for application of categories to the MBNF.

LANDFORM	ELEVATION				
	semi-arid	lower montane	montane	subalpine	alpine
Tablelands	1	2	3	4	5
Canyons	6	7	8	9	10
Valleys	11	12	13	14	15
Hills	16	17	18	19	20
Mountains	21	22	23	24	25

Table 3.3 **Medicine Bow National Forest Preliminary Subsections and Landtype Associations.** LTA category numbers are from Table 3.2. Subsection descriptions are in Appendix 18.

SIERRA MADRE MOUNTAINS	
Section 342F	Central Basin and Hills Section
Subsection 342Fd	Savory - Saratoga Valley Subsection Major Landtype Associations: 11,12,16,17
Section M331I	Northern Parks and Ranges Section
Subsection M331Iu	Park Range/Sierra Madre Subsection Major Landtype Associations: 7,8,9,13,14,17,18,19,20,24,25
MEDICINE BOW MOUNTAINS	
Section M331I	Northern Parks and Ranges Section
Subsection M331Iv	Medicine Bow Mountains Subsection Major Landtype Associations: 8,9,13,14,15,18,19,20,23,24,25
SHERMAN MOUNTAINS	
Section M331I	Northern Parks and Ranges Section
Subsection M331Ib	North Front Range Subsection Major Landtype Associations: 3,4,8,13,18,23
LARAMIE MOUNTAINS	
Section M331I	Northern Parks and Ranges Section
Subsection M331Ic	North Laramie Mountains Subsection Major Landtype Associations: 3,4,7,8,9,12,13,14,17,18,19,23,24
Subsection M331Ie	Rolling High Plains Subsection Major Landtype Associations: 3,13,18

The easternmost uplift includes the Laramie Mountains and Sherman Mountains which are continuous with the Front Range of Colorado. Four major, and three minor distinct areas of Precambrian rocks comprise the uplift the Sherman Mountains and Laramie Mountains. The rocks can be classed as plutonic rocks or metasedimentary/metavolcanic rocks (Love and Christiansen 1985). They are of Late Archaen rocks (greater than 2.5 billion years old) or rocks of Middle Proterozoic age (about 2.5 to 1.7 billions years old). Minerals include schist, gneiss, amphibolite, feldspar, and quartz. Metamorphosed sedimentary rocks include marble, metagreywacke and metaconglomerates. Mafic intrusive rocks are found throughout the area.

The Sherman Mountains consist mainly of Sherman granite, of Middle Proterozoic Age. Sherman granite is brittle with a high feldspar content that fractures in large blocks. The Vedavoo Rocks are a good example of this type. NFS lands in the Laramie Mountains are on older plutonic rocks of late Archaean age. The Sherman Mountains are bordered on the west by sandstones and limestones of the Casper and Fountain Formations, sedimentary rocks formed during the Permian and Pennsylvanian Periods. East of the uplift are Oligocene sediments which form the downward-sloping "Gangplank" to Cheyenne. NFS lands include some of the younger sedimentary rocks on the west side of the Pole Mountain Unit.

The Laramie Mountains consist of Late Archaen plutonic rocks north of a fault extending NE from Garrett, across the confluence of Bear Creek and the North Laramie River, through the Fletcher Park area and northeast to Horseshoe Creek. South of this line are Late Archaen metasedimentary rocks. Oligocene sediments surround the Laramie Mountains forming high plains at their bases and among the peaks. The high plains near Esterbrook, and along the Cold Springs Road in the LaPrele watershed are examples. Partially buried peaks jut from sediments along the edges of the range. This is especially evident at the southern end of the NFS lands in the vicinity of Laramie Peak. The Limestone, along Horseshoe Creek, is the only significant outcrop of sedimentary rock within the NFS boundary in the Laramie Mountains.

The Medicine Bow and Sierra Madre Mountains are much more complex geologically than the eastern range. A regional shear zone known as the Cheyenne Belt divides both mountain ranges approximately in half. Rocks north of the shear zone are mostly ancient, metamorphosed sedimentary rocks while those south of the zone are younger and mainly composed of metamorphosed sedimentary and volcanic rocks (Hausel 1993). The magnificent quartzite cliffs of Medicine Bow Peak are an example of rocks north of the shear zone. Volcanic gneiss, mafic complexes and granitic intrusives form the land base in most of Snowy Range South and most of the Sierra Madre south of the Battle Highway (Figure 3.4a).

Glaciers covered the high elevations of the Medicine Bow Mountains several times during the Pleistocene. Many glacial features including kettleholes, moraines, glacial erratics, stone nets, and polished rocks are found in all directions from Medicine Bow Peak. The Sierra Madre had less extensive glaciation. Battle Lake is in the base of a cirque. Bridger Peak was evidently a monadnock above the ice. Glaciers did not occur in the Laramie Mountains or Sherman Mountains. Some references on glacial geology include Atwood 1937; McCallum 1962; Mears 1962; Kiver 1968; Price 1973; Oviatt 1977; Mears 1995.

Many SW to NE trending surface faults characterize the Laramie Mountains. A major fault occurs through the Laramie Mountains trends NE from Garrett, WY to Horseshoe Creek just east of the Forest boundary. In the central Medicine Bow Mountains several faults are congruent with shear zones of the Cheyenne Belt trending NE from the vicinity of Savage Run, Mullen Creek and French Creek. Below-ground west-east trending faults occur in the northern Sierra Madre (Love and Christiansen 1985). There is a complex fault system in the Washakie Basin west of the Sierra Madre Mountains.

EARTHQUAKES

Earthquakes do occur in southeast Wyoming, with the potential for triggering landslides. Major landslide areas are in the western Sierra Madre mountains, and the northern Medicine Bow range extending from the Kennaday Peak area on the west to the Rock Creek area on the east. Further discussion of unstable land areas is in Appendix 14. Historic earthquakes in southeastern Wyoming are listed in Table 3.4 (Case 1991).

The Intensity Scale in Table 3.4 is a qualitative scale which measures effects which can be rated by description. The scale ranges from I (felt by a few persons) to XII where damage is total. Richter Scale ratings are provided for earthquakes since 1964 in the table. The highest maximum random earthquake expected in Wyoming would have an intensity of 6.1 on the Richter scale (Case 1991).

For comparison, the earthquake which triggered the Hebgen Lake slide on the Madison River in NW Wyoming in 1948 was an Intensity V earthquake and rated 7.5 on the Richter scale. The Hebgen slide was a rotational slide about a half-mile long which caused a hillslope of lodgepole pine forest to collapse into the river.

In summary, the geologic substrate beneath most of the Medicine Bow National Forest consists of acidic rocks which support coniferous forest of various types. The kind of forest in an area is determined by microclimatic and biotic factors since coniferous tree species are able to grow on a wide range of acidic rocks.

Table 3.4 Earthquakes in Southeastern Wyoming. (From Case 1991)

Place	Date	Intensity	(Richter)
Laramie	January 1, 1898	IV	
Laramie	September 21, 1931	IV	
Laramie	November 10, 1935	IV	
S. of Lusk, WY	February 25, 1942	V	
LaPrele Creek	April 14, 1947	V	
Esterbrook	August 22, 1952	IV	
Esterbrook	October, 1952	low	
12 mi NE of Laramie	January 20, 1954	V	
Jelm	January 23, 1954	IV	
near Guernsey	October 3, 1954	IV	
Jelm-Woods Landing	May 22, 1955	IV	
Jelm-Woods Landing	August 6, 1958	IV	
Foxpark	December 25, 1959	V	
NW of Lusk	October 22, 1964	V	(4.5)
N. Albany CO	February 13, 1983	IV	(4.0)
21 miles S. of Esterbrook	October 18, 1984	VI	(5.5)

Shrubs, especially mountain mahogany and three-leaved sumac, grow best on basic sedimentary rocks which are scarce within the forest boundary, and do not form very large areas outside the administrative boundary. This is in contrast to the Front Range of Colorado which has extensive areas of uneroded sedimentary rocks above granite substrates. Shrub vegetation is associated with the sedimentary rock.

CLIMATE

CLIMATE PATTERNS

The Medicine Bow-Routt National Forest includes very climatically diverse areas with regard to precipitation pattern and amount. Mean annual precipitation ranges from about 14 inches to over 50 inches per year. The Routt NF in portion in Colorado, consists mainly of high elevation areas, much of which is west of the Continental Divide. This receives high precipitation amounts, especially as winter snow. The Sierra Madre mountains on the Medicine Bow National Forest have a similar climate pattern but less snow. The rest of the Medicine Bow National

Forest, entirely east of the Contintental Divide is cold and dry with the exception of the area immediately around Medicine Bow Peak. Steep precipitation and temperature gradients extend downward from the alpine environments of Medicine Bow Peak. For detailed analyses of data from 32 weather stations (Figure 3.5) see Appendix 3. Data were obtained from the Wyoming Water resources Center (Laramie) and the Colorado Climate Center (Fort Collins).

The southern half of the Medicine Bow mountains are quite dry (16 inches annual precipitation at Foxpark - elevation 9065 feet) compared to the Sierra Madre (31 inches annual precipitation at Coon Creek - elevation 8800 feet). Pole Mountain (elevation 8530 feet) in the Sherman Mountains only receives about 13 inches a year precipitation, while the Laramie Mountains (Squaw Peaks Ranch in the Esterbrook area - elevation 6150 feet) receives about 21 inches. The Laramie Mountains are the most interior continental mountains in the Routt-Medicine Bow NF. Gulf moisture and the Arizona Monsoon, which are important sources of precipitation for Front Range ecosystems in Colorado contribute little to the moisture regime in the Laramie Mountains or the Medicine Bow Mountains. The Arizona Monsoon does provide moisture to the Sierra Madre Mountains, especially west of the Continental Divide. Storms from the southwest which consistently bring moisture to the western slope in Colorado and Wyoming also contribute low amounts of precipitation to the Laramie, the Sherman Mountains. The Laramie Mountains likely have the most variable climatic regime within the MBNF.

Differences in annual precipitation patterns are evident in climatograms for mountain stations on the MBNF and adjacent areas in Colorado (Figure 3.6). On these climatograms the bars show monthly precipitation amounts and the bell-shaped line shows the average monthly temperature. The horizontal line is at the 40 degrees F and two inches of moisture level. Additional climatograms are in Appendix 3.

Four major patterns characterize the climatograms. These illustrate seasonality and amount of precipitation (See Appendix 3 for further discussion).

1. U-shaped - heavy winter snow and most months with greater than two inches of precipitation (western slope pattern) (A, B, D, G, J - Fig. 3.6)

2. Flat - approximately the same amount of precipitation each month with most months having less than two inches of precipitation (Intermountain desert pattern) (E - Fig. 3.6)

3. Unimodal - increasing moisture January-May, decreasing moisture June-December (Great Plains pattern) (F, I, L - Fig. 3.6)

4. Bimodal - increasing moisture January-May with a second pulse occuring in July-August (Arizona Monsoon effect) or October-November. (Front Range pattern) (C, H, K Fig. 3.6)

The temperature curve shows the same general pattern for all sites. At high elevations such as Glacier Lakes (10,800 feet) there is very slow warming in spring but fast cooling in fall; at Columbine, Colorado (8700 feet) temperatures warm rapidly in the spring and cool slowly in the fall.

The data presented here are based on records of varying lengths. Glacier Lakes, Hohnholz Ranch, Pole Mountains, Coon Creek and Blackhall Mountain have short records (5 to 8 years) taken during the 1950s (Pole Mountain) or since 1984, both of which periods had series of years with warmer and drier conditions than a longer record might show. However, regional patterns show consistent differences for this period of record.

El Nino and La Nina cycles are large scale fluctuations in climate dependent on coupling of atmospheric and sea surface temperature phenomena. El Nino years tend to be wetter than average, while La Nina years are drier. El Nino climate signals are very strong in Mexico, New Mexico and Arizona (Molles and Dahm 1990). Wet years in these arid environments are important for regeneration of certain plant species such as ponderosa pine and black grama (Neilson 1986). The El Nino signal becomes weaker to the north, but is discernable in central Colorado (von Ahlefeldt 1992).

Two-year mean annual precipitation amounts for El Nino and La Nina years since 1957 for stations with adequate climate records o the MBNF indicate that El Nino years are generally consistently wetter than the mean while El Nina years are generally drier (Table 3.5). In New Mexico, El Nino years may have 300 per cent of the mean annual precipitation. The signal appears to be much weaker here (10-30 percent) (Table 3.5)

Although background variablity in year-to year precipitation is quite high and the range of precipitation is quite large, most of the highest precipitation years were also El Nino years (Table 3.6)

Heavy snowfall years may be followed by warm springtime temperatures causing high runoff over large areas such as the spring of 1995; summer convectional storms may deposit heavy rain over smaller areas causing flooding. These kinds of events have important impacts on riparian areas, populations of aquatic animals and streambanks. Information on these kinds of dynamics will be discussed for specfic areas later in the report.

Table 3.5 **El Nino and La Nina Years**. Total precipitation is in inches. NA means no data.

		El Nino		
Station	**Mean ppt.**	**1957-58**	**1972-73**	**1982-83**
Cheyenne	15.18	18.20	14.81	19.96
Double-4 Ranch	14.08	17.42	NA	18.65
Elk Mountain	12.29	14.00	17.10	13.36
Centennial	14.30	14.69	NA	15.26
Laramie	10.90	10.87	14.33	13.30
Saratoga	9.51	7.82	11.43	12.79
Encampment	14.28	16.00	16.10	15.55
		La Nina		
	Mean ppt.	**1954-55**	**1963-64**	**1970-71**
Cheyenne	15.18	12.90	10.42	25.73
Double-4 Ranch	14.08	10.76	12.51	NA
Elk Mountain	12.29	5.65	13.18	7.28
Centennial	14.30	12.18	11.52	NA
Laramie	10.90	8.46	8.07	9.70
Saratoga	9.51	6.32	8.67	8.20
Encampment	14.28	14.22	13.73	15.44

Table 3.6 **Extremes of annual precipitation, 1948-1993**.

Station	**Mean**	**Lowest**	**Year**	**Highest**	**Year**
Cheyenne	15.18	5.94	1964	20.69	1983
Double-4 Ranch	14.08	7.94	1954	22.03	1977
Elk Mountain Ranch	12.29	5.07	1987	19.31	1973
Laramie	11.53	6.96	1976	15.80	1983
Centennial	14.30	9.00	1966	19.68	1951
Saratoga	9.51	5.88	1971	14.50	1983
Encampment	14.28	9.79	1988	20.31	1961

Climatograms only show averages for precipitation and temperature. Other attributes of climate such as humidity, wind, solar radiation load due to slope and aspect, snow drift accumulation and melt patterns, growing season, nighttime temperatures, anomalous freezing events and timing of precipitation on shorter time scales are extremely important in determining vegetation biological diversity. For example, ponderosa pine seedlings cannot withstand freezing nighttime temperatures as well as lodgepole pine, thus limiting both latitudinal and altitudinal distributions (Cochran and Berntsen 1973).

CLIMATE EFFECTS ON PLANTS

Numerous studies on the physiology of subalpine fir and Engelmann spruce have been conducted or are in progress on the MBNF. Many of these studies are concerned with seedling mortality and establishment and environmental limitations to plant growth (Knapp and Smith 1982; Smith 1984: Carter 1985; Delucia 1986; Delucia and Smith 1987; Carter and Smith 1987; Schoettle 1990; Cui 1991; Cui and Smith 1990; Cui and Smith 1991). This information has bearing on regeneration, especially of spruce and fir at high elevations. Understanding basic processes will contribute to the ability to predict vegetation behavior under conditions of climate change. Additional references on vegetation behavior in response to climatic limitations on the Medicine Bow National Forest can be found in Appendix 1.

CLIMATE CHANGE

A detailed discussion of possible effects of climate change on biological diversity, possible effects of timber harvest on carbon dioxide levels, and secondary effects on climate is beyond the scope of this report. However, a few concepts will be reviewed to address this issue.

A variety of possible changes in climate parameters other than temperature may accompany global warming. Amount, timing, and seasonality of precipitation, wind, and changes in humidity are important for vegetation. These can interact with enriched carbon dixoide levels. Graumlich (1991) investigated increased growth in subalpine conifers in the Sierra Nevada Mountains as a result of possible enriched levels of carbon dioxide. His results did not confirm that elevated carbon-dioxide levels increased growth, but he found maximum growth rates in subalpine trees occurred with high winter precipitation and warm summers.

The role of temperate forests in the global carbon dioxide balance and the possible effects of timber harvest was reviewed by Musselman and Fox (1991). First order climate effects would be global warming and regional decreases in

moisture. Other effects would be changes in the frequency of forest disturbances such as fire, insects, and disease incidence. They suggested that first-order effects of increased carbon dioxide levels on vegetation would be the direct effect of carbon dioxide fertilization on photosynthesis and indirect effects of increased carbon dioxide on water and nitrogen use efficiency and carbon allocation. Length of the fire season in a change climate was modeled by Wotton and Flannigan (1993) for Canadian forests. Their results suggested that increasing fire frequencies and severities could be expected in some ecosystems.

Much uncertainty exists as to the characteristics of global climate change for specific areas and there are few definitive studies on ecosystem responses. Climate change becomes an extremely difficult variable in discussions of the range of "natural" variablity since a shift to a different climate context affects nearly every aspect of ecosystem composition, structure, process and function. Length of reliable climate records is much shorter than the period of stand history for most old forests (200-400 years) in the Rocky Mountains. Assessment of climate change and its effects on existing biological diversity must be an ongoing effort, the results of which belong largely to the future.

Climate modification to augment water yield by increasing winter snowpack through cloud seeding was under serious consideration in the mid-1970s. The Final Report of The Medicine Bow Ecology Project - *The Potential Sensitivity of Various Ecosystem Components to Winter Precipitation Management in The Medicine Bow Mountains*, Wyoming (Knight et al. 1975) contains results of several years of baseline ecological and physiological measurements on vegetation components to determine possible effects of changing amount and seasonality of winter precipitation as well as possible modification of microclimate factors. Subjects studied included impact of augmented snowpack on elk, mule deer, fish, herbaceous and shrubby subalpine vegetation, subalpine lake processes, litter decomposition, and nutrient leaching. Ecosystem effects of silver iodide were also investigated. Due to economic, political, and legal considerations, cloud seeding has not been pursued.

LITERATURE CITED

Atwood, W.W., Jr. 1937. Records of Pleistocene glaciers in the Medicine Bow and Park Ranges. Journal of Geology 45(2): 663-673.

Bailey, R.G.; Avers, P.; King, T.; McNab, W. 1994. Ecoregions and Subregions of the United States. (Map). USDA Forest Service. Washington, D.C.

Bauer, A.; Edwards, M.; Hudnell, L. 1989. Soil Survey of the Medicine Bow National Forest, Wyoming. Medicine Bow Mountains and Sierra Madre Mountains Areas. (Draft Report) USDA Forest Service. Medicine Bow National Forest. Laramie, WY.

Carter, G.A. 1985. Ecophysiology of *Picea engelmanii, Abies lasiocarpa and Pinus contorta* in the Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Wyoming.

Carter, G.A.; Smith, W.K. 1987. Microhabitat comparisons of transpiration and photosynthesis in three subalpine conifers. Canadian journal of Botany 66: 963-969.

Case, J. C. 1991. Historic earthquakes in southeast Wyoming. Geo-Notes No. 29: 41-45.

Cochran, P.H.; Berntsen, C.M. 1973. Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures. Forest Science:19(4): 272-280.

Cui, M. 1991. The ecophysiology of seedling establishment in subalpine conifers on the Central Rocky Mountains, U.S.A. PhD Dissertation. University of Wyoming.

Cui, M.; Smith, W.K. 1990. Photosynthesis and water relations of young seedlings of *Abies lasiocarpa* with high natural mortality. Tree Physiology 8: 37-46.

Cui, M.; Smith, W.K. 1991. Seedling microenvironment, gas exchange and survival during first year establishment in subalpine conifers. Tree Physiology 10: 44-53.

DeLucia, E.H. 1986. Effect of low root temperature in net photosynthesis, stomatal conductance and carbohydrate composition in Engelmann spruce (*Picea emgelmannii*) seedlings. Tree Physiology 2: 143-154.

DeLucia, E.H.; Smith, W.K. 1987. Air and soil temperature limitations on photosynthesis in Engelmann spruce during summer. Canadian Journal of Forest Research 17: 527-533.

Edwards, M.R. 1989. Soil Survey of the Pole Mountain Area, Medicine Bow National Forest, Wyoming (Draft Report). USDA Forest Service Medicine Bow National Forest, Laramie, WY.

Edwards, M. R. 1992. Soil Survey of the Laramie Peak Unit, Medicine Bow National Forest, Wyoming Survey Area 622 (Interim Report 4/92). USDA Forest Service. Medicine Bow National Forest Laramie, WY.

Freeouf, J. 1995. Memo regarding tentative Subsection names. From Regional Soil Scientist, Region 2, Lakewood, CO.

Graumlich, L.J. 1991. Subalpine tree growth, climate and increasing $C0_2$: an assessment of recent growth trends. Ecology:72(1): 1-11

Hausel, W.D. 1993. Guide to the geology, mining districts and ghost towns of the Medicine Bow Mountains and Snowy Range Scenic Byway. Geological Survey of Wyoming Public Information Circular No. 32 Laramie, WY.

Hausel, W.D. personal communication. Geological Survey of WY. Laramie, WY.

Houston, R.S. 1968. A regional study of rocks of Precambrian Age in that part of the Medicine Bow Mountains lying in southeastern Wyoming - with a chapter on the relationship between Precambrian and Laramide structure. Wyoming Geological Survey Memoir 1, Laramie, WY.

Houston, R.S.; Ebbett, B.E. 1977. Geological map of the Sierra Madre and Western Medicine Bow Mountains, southeastern Wyoming. Wyoming Geological Survey Map 1:125,000.

Houston, R.S.; Karlstrom, K.E. 1992. Geological map of Precambrian metasedimentary rocks of the Medicine Bow Mountains, Albany and Carbon Counties, Wyoming U.S. Geological Survey Miscellaneous Investigations Series Map I-2280.

Houston, R.S.; Karlstrom, K.E.; Graff, P.J.; Flurkey, A.J. 1992. New stratigraohic subdivisions and redefinition of subdivisions of late Archaen and early Proterozoic metasedimentary and metavolcanic rocks of the Sierra Madre and Medicine Bow Mountains, Southern Wyoming. U. S. Geological Survey Professional Paper 1520.

IRI - Integrated Resources Inventory. February 3, 1995. Chapter 4 Common Land Unit. Draft. USDA Forest Service Region 2 Lakewood, CO.

Kiver, E.P. 1968. Geomorphology and glacial geology of the southern Medicine Bow Mountains, Colorado and Wyoming. University of Wyoming.

Knapp, A.K.; Smith, W.K. 1982. Factors influencing understory seedling establishment in subalpine conifers. Tree Physiology 10: 44-53.

Knight, D.H. et al. 1975. The Medicine Bow ecology project. University of Wyoming. Laramie, WY

Knight, S.H. 1990. Illustrated geologic history of the Medicine Bow Mountains and adjacent regions. Geological Survey of Wyoming Memoir 4 Laramie, WY.

Love, J.D.; Christiansen, A.C. 1985. Geologic map of Wyoming. USGS.

McCallum, M.E. 1962. Glaciation of Libby Creek Canyon, east flank of the Medicine Bow Mountains, Southeastern Wyoming. Contributions to Geology 1(1): 21-29.

McNab, W.H. and P.E. Avers. 1994. Ecological Subregions of the United States: Section Descriptions WO-WSA-5 USDA Forest Service Washington, D.C.

Mears, B., Jr. 1962. Stone nets on Medicine Bow Peak, Wyoming. State Geological Survey Short Notes 1:48.

Mears, B., Jr. 1995. Glacial records in southeastern Wyoming: Precambrian tillites in the cores of the Medicine Bow Moutains and Sierra Madre. The Geological Survey of Wyoming (In Review).

Marston, R.A.; Clarendon, D.T. 1988. Land systems inventory of the Medicine Bow Mountains and Sierra Madre, Medicine Bow National Forest, Wyoming. USDA Forest Service Research Paper, MBNF-88-01. Laramie, WY.

Molles, M.C.; Dahm, C.H. 1990. A perspective on El Nino and La Nina: Global implications for stream ecology. Journal of the North American Benthological Society 9: 68-76.

Musselman, R.C.; Fox, D.G. 1991. A review of the role of temperate forests in the global CO_2 balance. Journal of the Air and Waste Management Association 41(6): 798-807.

Neilson, R.P. 1986. High resolution and climatic analysis and southwest biogeography. Science 232: 27-34.

Oviatt, C.G. 1977. Glacial geology of the Lake Marie area, Medicine Bow Mountains. Contributions to Geology 16(1): 27-38.

Price, C. 1973. Glacial and drainage history of the upper Cow Creek drainage, Sierra Madre, Wyoming. Master's Thesis. University of Wyoming.

Reiners, W.A.; Thurston, R.C. 1995. Delineations of Landtype Associations within the Great Plains Physiographic Province of Wyoming. Final Report. Department of Botany, University of Wyoming for the Bureau of Land Management, Cheyenne, WY.

Schoettle, A.W. 1990. Importance of shoot structure to sunlight interception and photosynthetic carbon gain in *Pinus contorta* crowns. PhD Dissertation. University of Wyoming.

Smith, W.K. 1984. Environmental limitations on leaf conductance in Central Rocky Mountain conifers. IN: Establishment and Tending of Subalpine Forest. H.Tutner and W.E. Tranquillini (eds) Eidg. Anst. Forstl. Versuchwes Rev. 270: 95-101.

von Ahlefeldt, J.P. 1992. The landscape ecology of the Palmer Divide. PhD Thesis. Colorado State Unviersity, Fort Collins, CO.

Wotton, B.M.; Flannigan, M.D. 1993. Length of the fire season in a changing climate. The Forestry Chronicle 69(2): 187-192.

USDA Forest Service. 1995. Memo to Forest Supervisors - Feb. 2, 1995 File 2090/2550 Framework for delineating and describing Land Type Associations (LTA's).

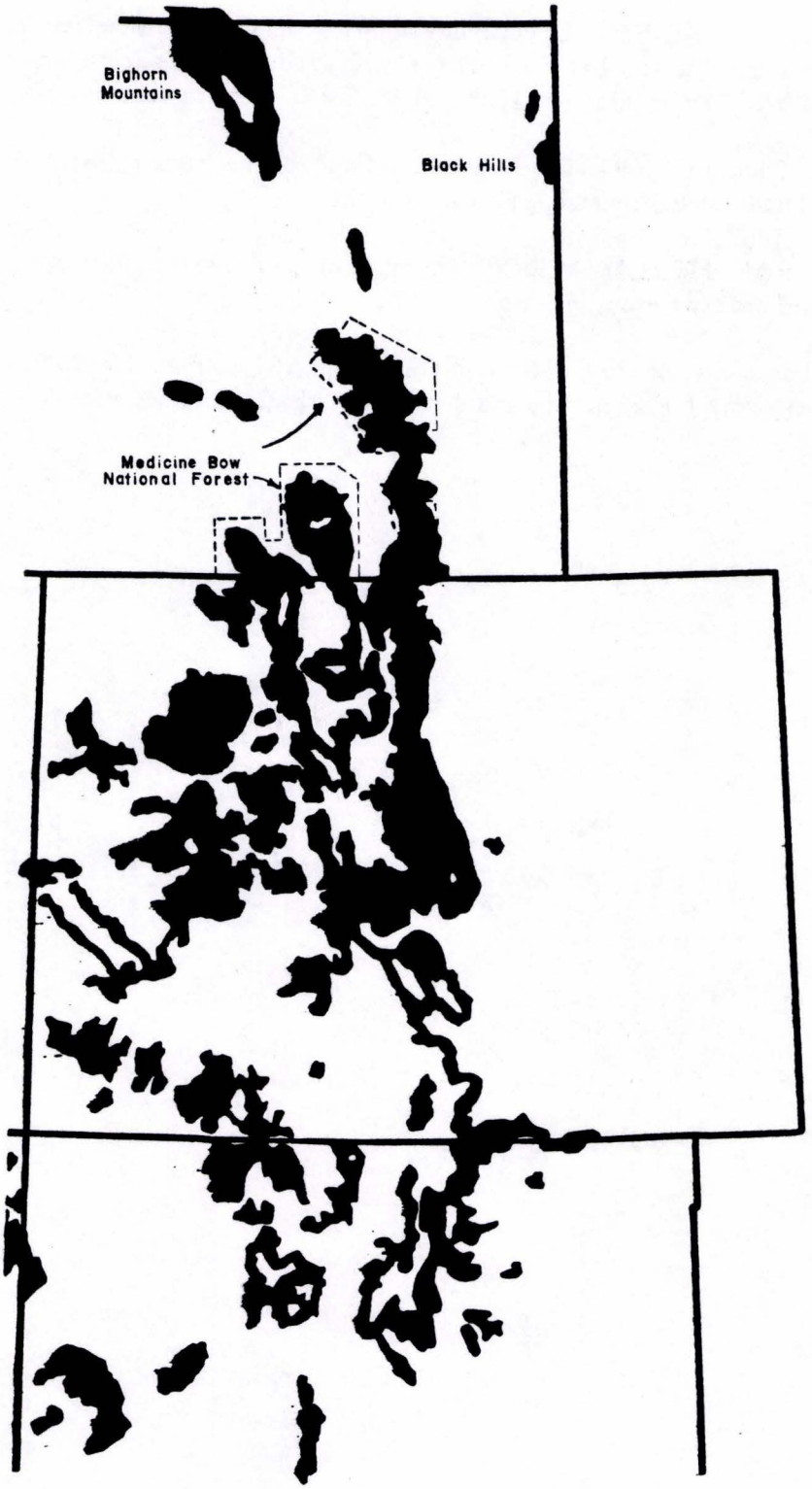


FIGURE 3.1 Forested mountain areas in Northern New Mexico, Colorado and Southern Wyoming (After Kuchler, 1964).

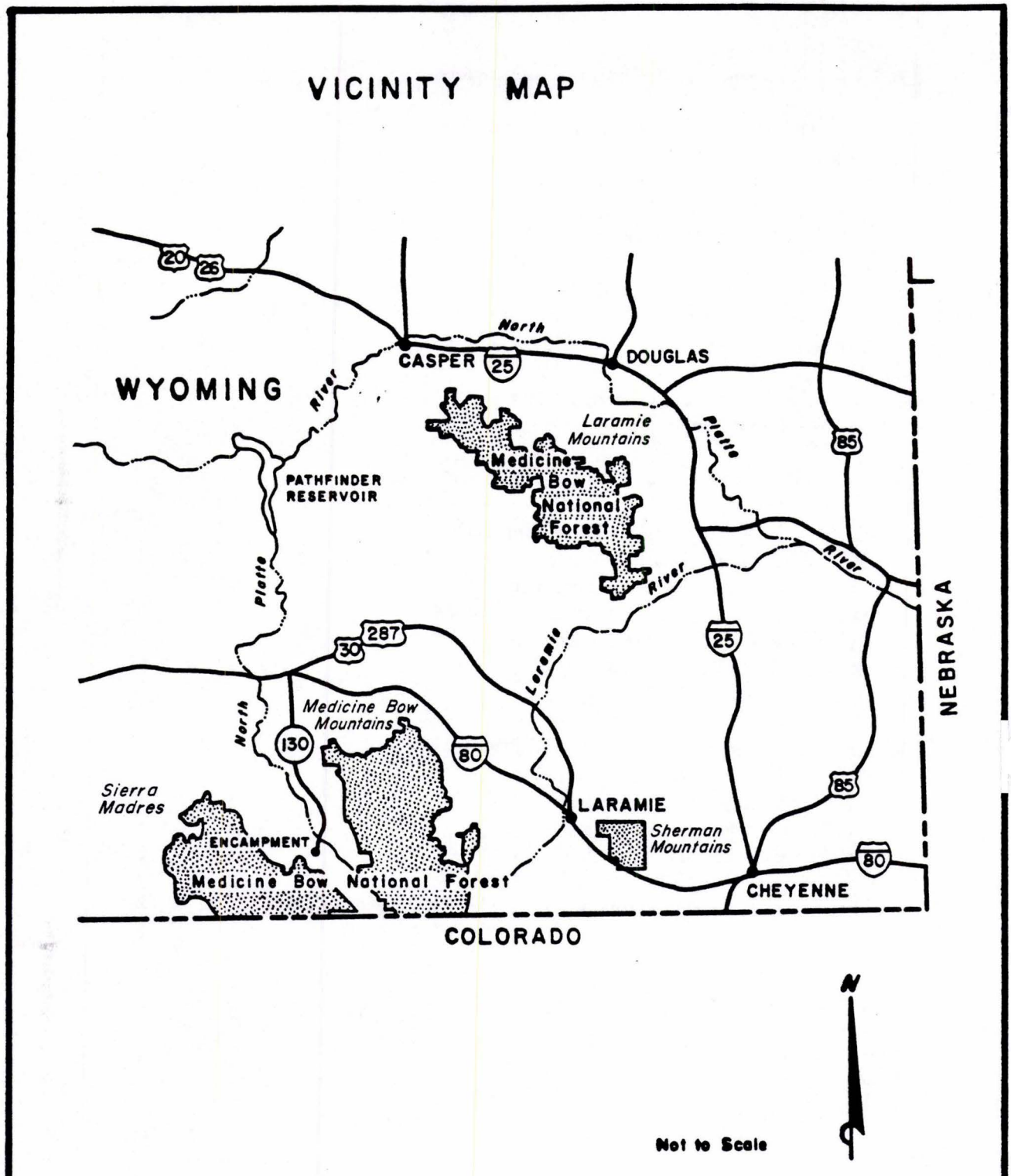


FIGURE 3.2 Vicinity map - Medicine Bow National Forest.

FIGURE 3.3 Legend for Preliminary Subsections.*

Section 331F Northwestern Great Plains Section
Subsection:
- 331Fm - Rolling Plains Subsection
- 331Fk - High Plains Subsection
- 331Fn - Hartville Uplift Subsection

Section 331G Powder River Basin Subsection
- 331Ga - Central Powder River Basin Subsection
- 331Gb - Not named

Section 331H Central High Plains Section
- 331Ha - Denver-Julesburg Basin

Section M331I Northern Parks and Ranges Section
Subsection:
- M331u - Park Range/Sierra Madre Subsection
- M331v - Medicine Bow Mountains Subsection
- M331b - North Front Range Subsection
- M331c - North Laramie Mountains Subsection
- M331e - Rolling High Plains Subsection
- M331f - North Front Range Foothills Subsection

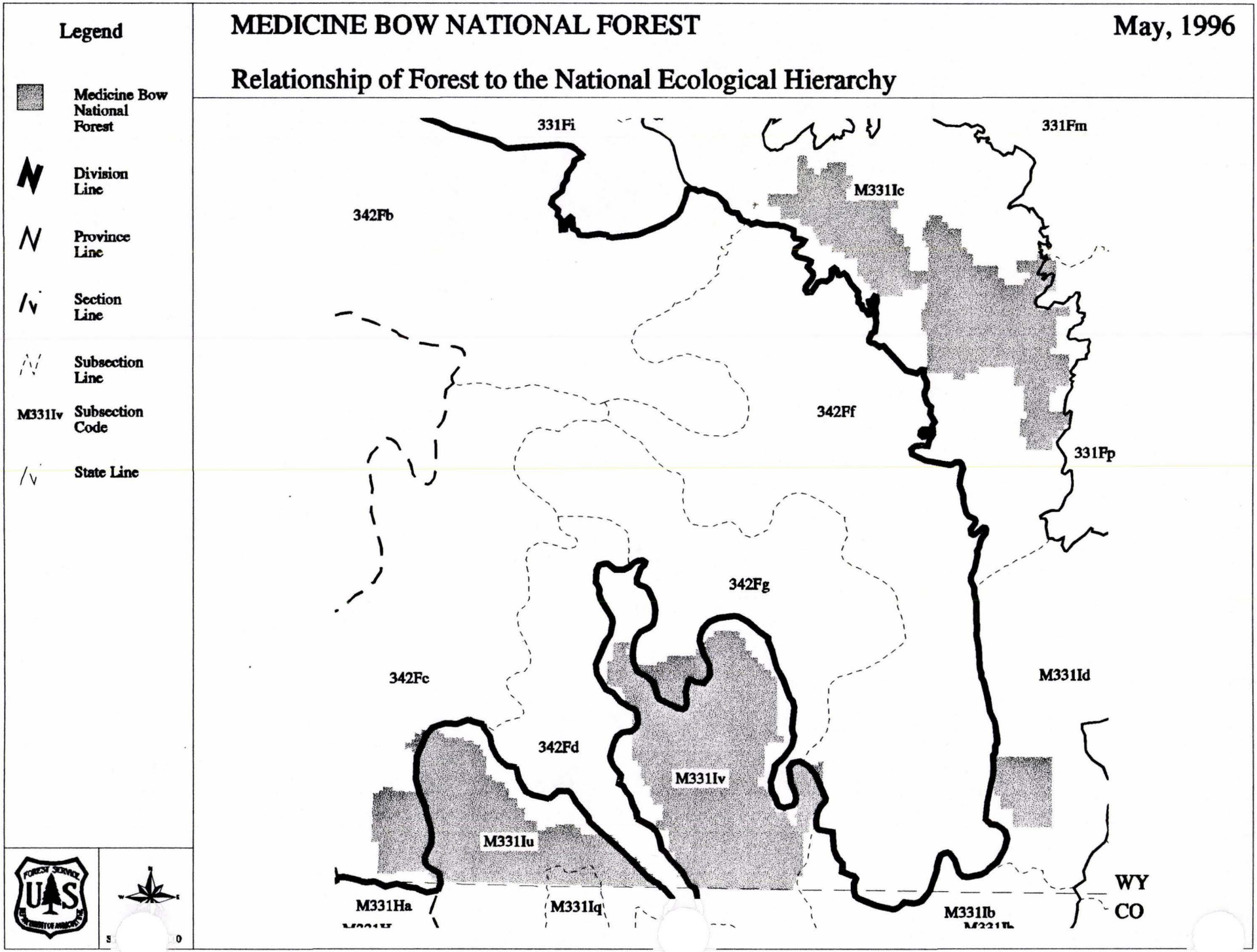
Section 342F Central Basin and Hills Section
- 342Fd - Saratoga-Red Desert Subsection
- 342Fe - Shirley Basin Subsection
- 342Ff - Laramie Plains subsection
- 342fG - Hanna Basin Subsection

* Tentative names for Subsections as of May 9, 1995 (Freeouf Personal communication)

MEDICINE BOW NATIONAL FOREST

May, 1996

Relationship of Forest to the National Ecological Hierarchy



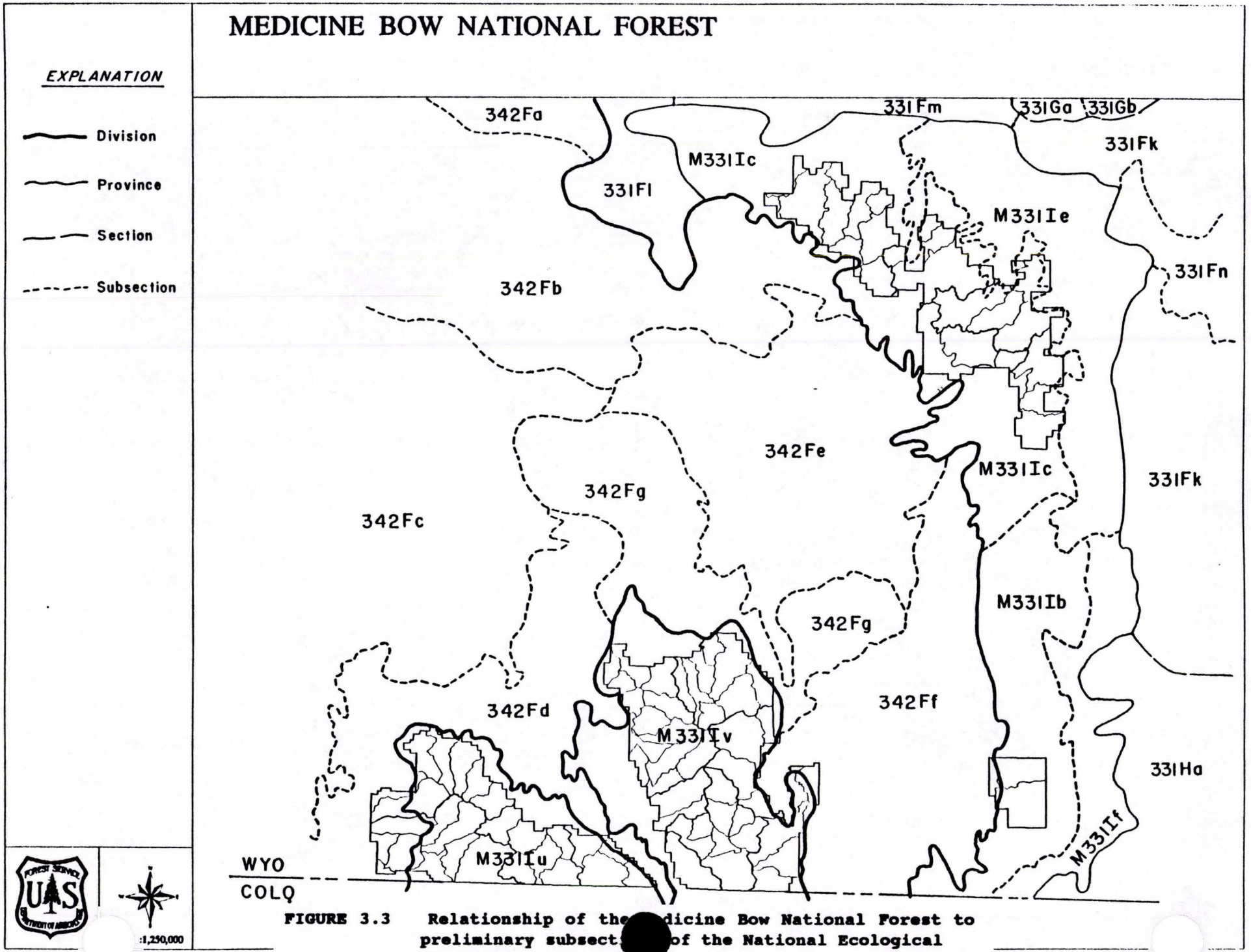


FIGURE 3.3 Relationship of the Medicine Bow National Forest to preliminary subsections of the National Ecological Hierarchy (USDA Forest Service).

UPDATE FOR FIGURE 3.3 - Preliminary Subsections June 25, 1996

Comparison of Section and Subsection names and lines between January, 1995 preliminary edition (used in revison Chapter 3 of von Ahlefeldt and Speas May 1996), and the map and Subsection names printed on a map from the Regional Office (RO) end of May, 1996. The RO May, 1996 map and lines are also subject to further changes. The preliminary subsection descriptions in Appendix 18 of von Ahlefeldt and Speas, 1996 will need to be adapted to these changes. The Region has not yet provided descriptions for the May, 1996 subsections.

As listed in von Ahlefeldt and Speas, 1996 (Figure 3.3 and Appendix 18)	**As listed on RO map May, 1996 map**
Section 331F Northwestern Great Plains Section	
Subsection:	
331Fm - Rolling Plains Subsection	331Fm Central Wyoming Rolling High Plains
331Fk - High Plains Subsection	331Fp Western Central High Plains
331Fn - Hartville Uplift Subsection	Included in 331Fm
Section 331G Powder River Basin Subsection	
Subsection:	
331Ga - Central Powder River Basin Subsection	331Gf Southern Powder River Basin Scoria Hills for both 331Ga
331Gb - Eastern Powder River Basin Subsection	and 331Gb)
Section 331H Central High Plains Section	
Subsection:	
331Ha - Denver-Julesberg Basin	331Hf Denver-Julesberg Basin; 331Ha Southern Denver-Julesberg Basin (Not on new map)

As listed in von Ahlefeldt and Speas, 1996 (Figure 3.3 and Appendix 18)	**As listed on RO map May, 1996 map**
Section M331I Northern Parks and Ranges Section	
Subsection:	
M331u - Park Range-Sierra Madre Subsection	M331Iu Park-Sierra Madre Ranges M331Iq Mount Zirkle Range
M331v - Medicine Bow Mountains Subsection	M33IIv Medicine Bow Mountains
M331b - North Front Range Subsection	M331Id South Laramie Mountains M331Ib North Front Range
M331c - North Laramie Mountains Subsection	M331Ic North Laramie Mountains
M331e - Rolling High Plains Subsection	Included with M331Ic and 331Fm and 331Fp
M331f - North Front Range Foothills Subsection	331He North Front Range Foothills (ends near WY/CO state line. Now included in 331Ha and 331Hf M331Ha Elkhead Mountains (new)
Section 342F Central Basin and Hills Section	
Subsection:	
342Fb - not named	342Fb Granite Mountains
342Fc - not named	342Fc Rawlins Uplift
342Fd - Saratoga-Red Desert Subsection	342Fd Savory-Saratoga Basin
342Fe - Shirley Basin Subsection	342Ff Laramie-Shirley Basin
342Ff - Laramie Plains subsection	342Ff Laramie-Shirley Basin
342Fg - Hanna Basin Subsection	342Fg Hanna Basin

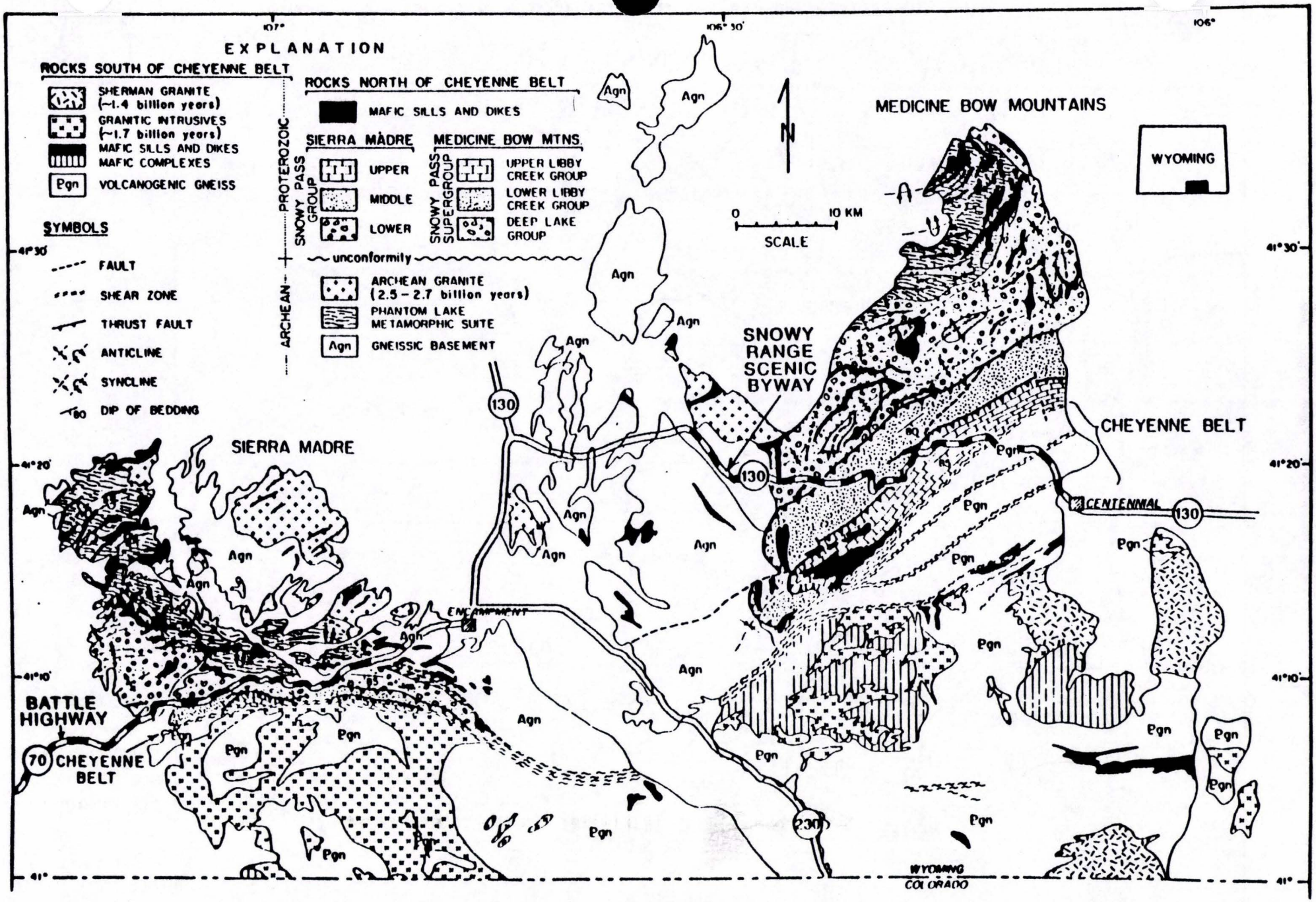


FIGURE 3.4a Generalized geology map of Precambrian Rocks - Sierra Madre and Medicine Bow Mountains. Double lines are State highways. From Hausel (1993).

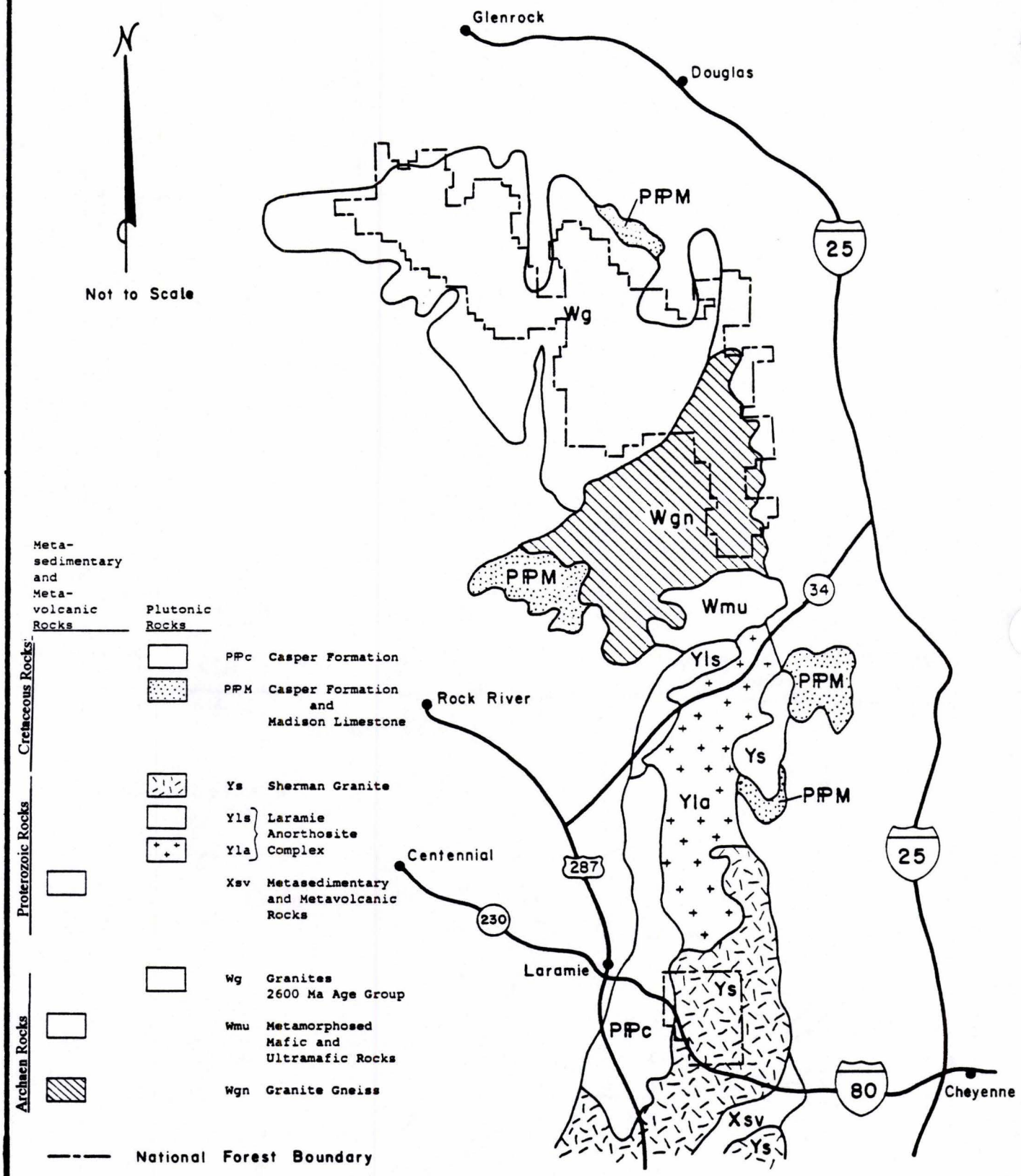


FIGURE 3.4b Generalized geology map of Precambrian and Cretaceous rocks of the Laramie Mountains in the vicinity of the Pole Mountain Unit of the Laramie Ranger District and the Laramie Peak Unit of the Douglas Ranger District. Modified from Love and Christiansen (1985).

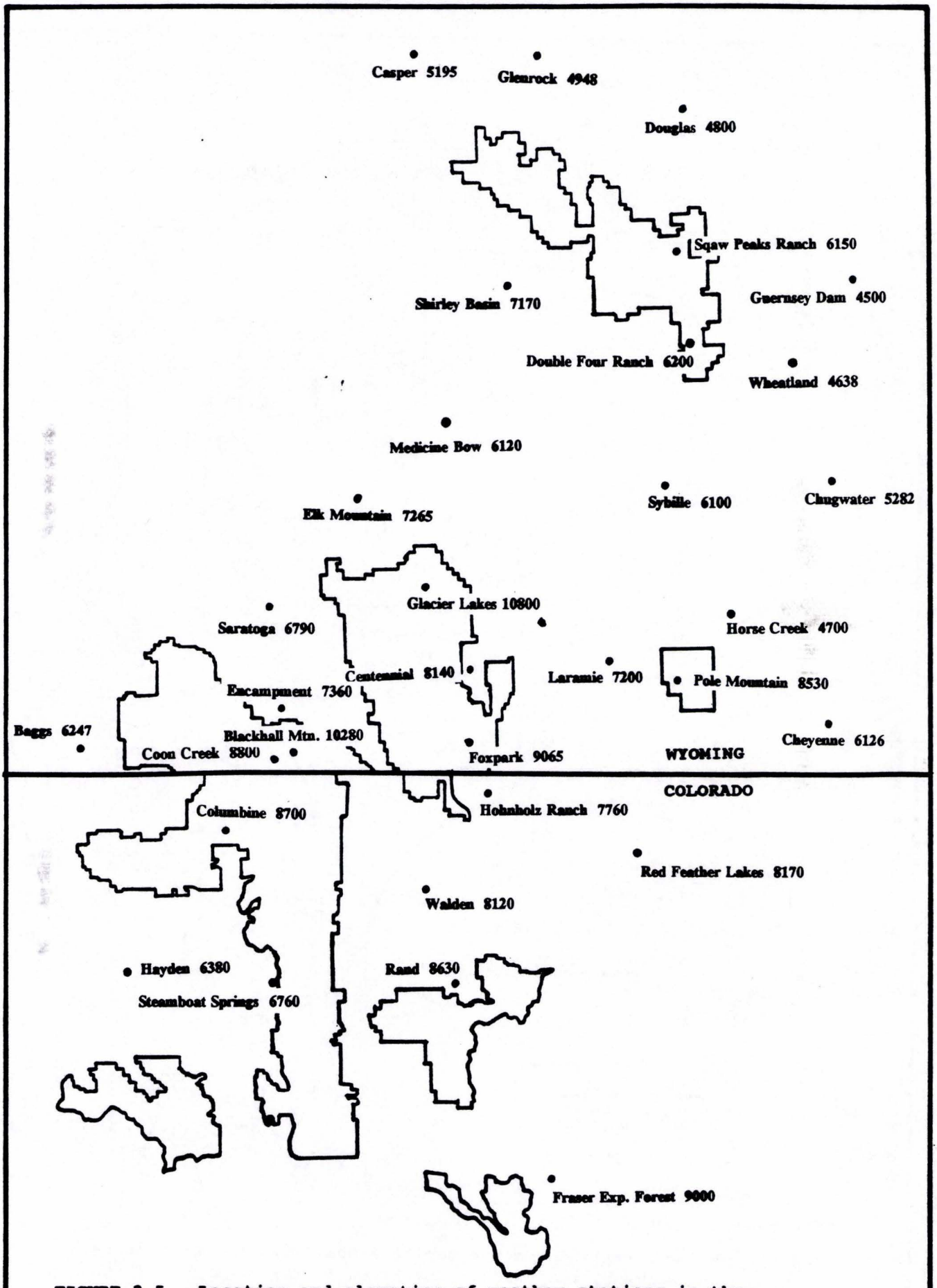


FIGURE 3.5 Location and elevation of weather stations in the vicinity of the Medicine Bow National Forest.

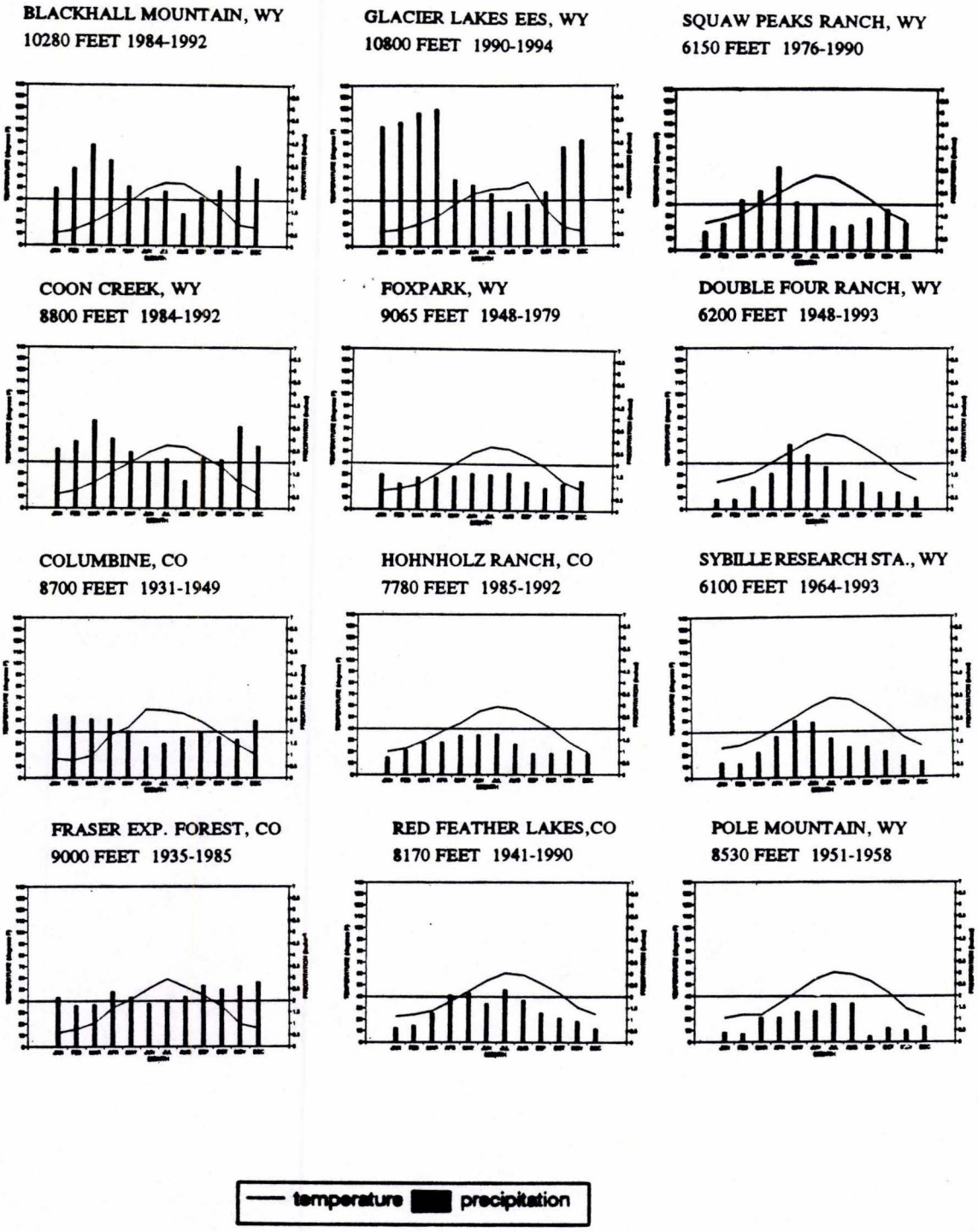


FIGURE 3.6 Climatograms for selected mountain weather stations on or near the Medicine Bow National Forest. (See Appendix 3).

CHAPTER 4

HISTORICAL ECOLOGY OF THE MEDICINE BOW NATIONAL FOREST

INTRODUCTION

Excellent accounts of the history of the MBNF are available. Some are: 1) archaeological information (Fawcett and Francis 1981; Grasso et al. 1981), 2) general historical information (Armstrong 1935; Bruce 1959; Thybony et al. 1986; Duncan 1992), 3) tie hacking (Pinkerton 1981; Wood 1988; Young et al. 1989; Young et al. 1994), and 4) mining (Houghton 1904; Duncan 1990). Primary source information for landscapes of southeastern Wyoming and what is now the MBNF can be found in government reports prior to 1900 (Hayden 1871; Ensign 1888; Fernow 1888), writings of early explorers (Parkman 1950; Martin 1951) and reports prepared in the first few decades of National Forest Administration (Dunlap 1906; Blackhall 1909; Lovejoy 1909; Mullison 1909; Mullison and Lovejoy 1909; Blackhall 1915; Duthie 1916). Chronologies of historic events affecting biological diversity and ecological integrity are in Appendix 19.

The Medicine Bow Collection in the American Heritage Center, University of Wyoming, has over 30 boxes of Forest reports, articles and photographs about the MBNF. Museums at Encampment, Wheatland, Laramie, and Douglas and the State Archives in Cheyenne, Wyoming, also contain historical information.

Natural and human-induced events which have contributed to the present state of biological diversity are presented in this chapter. Emphasis is placed on historical description of terrestrial and aquatic ecosystems and disturbance processes. Information is often incomplete and inference is necessary to reconstruct patterns. Sometimes information from similar ecosystems in other areas must be used.

Since 1991 there has been interest in "the range of natural variability" (RNV), a concept which describes the composition, structure, processess and functions of ecosystems in the absence of influences of modern technological man (approximately since the arrival of fur trappers in the west - circa 1800 for southern Wyoming). General discussion of the RNV concept can be found in Swanson et al. 1993, Covich et al. 1994, and Morgan et al. 1994. RNV has been addressed in most previous Forest Service reports in terms of fire regimes, vegetative composition, and populations of native vertebrate species (USDA Forest Service 1991; Carahar et al. 1992; USDA Forest Service 1994; Neelan et al. 1994; USDA Forest Service 1995). RNV is addressed in this and other

chapters of this report, but in the context of known and inferred historical variation, rather than as an assumption of what is or is not "natural."

ROCKY MOUNTAIN PALEOCLIMATES AND PALEOECOLOGY

Present biological diversity has existed for a relatively short time period compared to changes over geologic time since the evolution of flowering plants (end of the Cretaceous Period) about 66 million years ago, or since the last glacial maximum less than 18,000 years ago.

DIVERSITY OF VEGETATION OVER GEOLOGIC TIME

Vegetation development in North America over geologic time is discussed in *The Flora of North America*, Volume 1 (Flora of North America Committee 1993). The biological diversity we have now is a product of the longevity of ecological conditions and the number of times communities have undergone both long-term and short-term changes (Ross 1972). Plant and animal communities as we know them today are transitory assemblages of species that are responsive to climate change and disturbance (Hunter et al. 1988; Berglund 1986; Ritchie 1987; Pielou 1991).

Replacement of one form of vegetation by another was the rule throughout the past 380 million years. Fossil floras are known from the Early Devonian (385 million years ago) to the Early Cretaceous (110 million years ago) near the Rocky Mountains from southern Utah through central Colorado, Wyoming, Montana, and southern Alberta (Miller 1987).

Flowering plants did not appear until near the end of the Cretaceous period. Post-Cretaceous animal fossils are well represented throughout the Intermountain Area and the Great Plains. Megafossil floras from the Intermountain and Northern Rocky Mountain area (Utah, Colorado, Wyoming, Montana, and southern Alberta and Saskatchewan) provide the longest and most complete sample of data on flowering plant evolution from the Cretaceous Period through the Eocene anywhere in the world (Crabtree 1987; Wing 1987; McClammer and Crabtree 1989).

Origins of Rocky Mountain and Great Plains flora since the Eocene have been synthesized by Dix (1964) and Axelrod and Raven (1985). From the Eocene to the present, the area from northwestern Mexico northward to southern Montana including the Intermountain and Rocky Mountain areas, was an ecotone between forest and woodland-scrub vegetation. Members of the Madro-Tertiary flora from the southwest, such as prickly pear cactus, yucca, and pinyon pine moved northward during the Oligocene and Miocene times prior to the uplifts which

formed the Rocky Mountains. Mountain-building during the Miocene was accompanied by increasing aridity, climatic cooling, and glaciation at higher elevations. Cold-wet (pluvial) conditions existed in the in the Great Basin during the Pliocene. These conditions eliminated many eastern species and encouraged speciation and adaptive radiation of species which survived these climate changes.

POST-PLEISTOCENE CHANGES

The end of the last glacial advance is estimated to have been about 18,000 years ago. After glaciers retreated, there were waves of extinctions of large mammals in North America between about 12,000 and 9,000 YBP (years before present). From Pielou (1991):

> As the ice disappeared, life found its way into the strange landscape. Vegetation gradually took over the newly exposed ground, enabling animal immigrants to survive. The animals, especially the large mammals, would have been as unfamiliar as the scenery to modern eyes. Mastodons, mammoths, sabretooth cats, and giant short-faced bears were among the most spectacular. The small human population of 10,000 years ago may be to blame, at least in part, for their extinction. Our continent is the poorer for their disappearance; a knowledge of what we have lost should spur us to greater efforts to protect what remains: the grizzly bears, polar bears, cougars, bighorns and other species that still survive, precariously, in what wild land remains to us (Pielou 1991, page 2).

Prior to ice ages, the climate was warmest over North America during the Thermal Maximum in Eocene through mid-Miocene time. This climate supported vegetation such as sequoia trees, now found as fossils in Florissant, Colorado. Repeated major glaciations occurred from 100,000 to 18,000 YBP during the Pleistocene. Smaller, shorter climatic fluctuations have occurred since the last glaciation including Altithermal time (7000-4000 YBP), drought (about 1300 AD) and the Little Ice Age (1200 AD to 1900 AD in various locations) (Bradley and Jones 1992. These climate factors interacted with vegetation and animal populations to produce modern flora and fauna as a complex result of long-term ecological conditions and processes.

Three climatic controls of importance during the last 14,000 years were identified by Whitlock (1993): 1) direct cooling because of the presence of glacial recession, 2) northward shift of the jet stream causing wetter conditions that encouraged the development of conifer forests, and 3) amplification of the

seasonal cycle of solar radiation which encouraged development of vegetation adapted to dry conditions.

Origins and present day flora of the northern Rocky Mountains have been reviewed by Wolfe (1987) and Habeck (1987). While their discussions address vegetation from northwest Wyoming through southwestern Canada, the same concepts apply to the ecosystems of the MBNF. Many plants found in Eocene through Oligocene fossil records (such as willow, alder, elderberry, and coniferous species) are still present in southern Rocky Mountain flora. Evidence suggests that the Rocky Mountains were probably continuously occupied by coniferous forest from the Miocene through the present, below the line of Pleistocene glaciation.

Most research on assemblages of post-Pleistocene plant communities of North America has been done in the Southwest, the Great Basin, Canada, and the eastern United States (Baker 1983; Webb 1987; Grayson 1993). In the southwestern U.S. most data consists of fossil pollen assemblages (palynology) and pack rat midden composition. Suspected lag of vegetation response to climate change, and uncertainity of how pollen rain varies, makes assessment of the coupling of biological diversity to climate difficult (Wright 1976; Ritchie 1986; Davis 1989).

The post-glacial vegetation and climate of Grand Teton and Yellowstone National Parks is described by Whitlock (1993). The pollen record there suggests that alpine and high elevation shrub communities were present on the Yellowstone Plateau after the glaciers receded ~ 14000- ~ 11000 YPB. Common juniper and then spruce colonized the area as warming occurred. Spruce parkland was followed by denser forests of fir and whitebark pine at higher elevations and lodgepole pine at lower elevations. During the Altithermal upper timberline was higher than present and a series of forests, with spruce and whitebark pine at high elevations, followed by lodgepole pine and then Douglas fir and aspen, were found. Since about 5000 YBP, Douglas-fir and aspen were largely eliminated and the dominant forests became lodgepole pine at lower altitudes and spruce-fir in higher areas.

Several periods of fluctuation in upper timberline, in response to climatic variations, have occurred since 9000 YBP. Studies of Holocene insect fossils and plant macrofossils that track timberline shifts (Rocky Mountain National Park, Colorado) suggest that upper timberline is especially sensitive to climate change (Elias 1985). Upper treeline is strongly influenced by temperature limiting factors, while lower limits are presumably controlled by both temperature and moisture.

From 9000 to 7000 YBP, after glaciers melted, upper timberline was lowest. Upper timberline rose during the warm Altithermal time from 7000 to 4500 YBP. From 4500 to 3100 YBP it declined, then rose again, until 2000 years YBP. This has been followed by gradual decline 1000 years ago to below the level of 7000 BP. The evidence suggests that the past few centuries have been relatively cold. This hypothesis is based on data from Jasper, Alberta (Canada), from southern Colorado, and from LaPoudre Pass northwest of Fort Collins (Elias 1985).

Pollen analysis from a peat bog near Crested Butte, Colorado, showed that the lower limit of Englemann spruce-subalpine fir forests was at least 400 feet lower in elevation during the Altithermal (about 7000 to 4000 years YBP). The upper treeline limit was also higher. Climatic cooling and drying since the Altithermal constricted the elevational range of subalpine forest at both the upper and lower limits. Species such as sphagnum moss began to decline since 5000 years YBP, indicating development of drier conditions. Today, a peat bog which contained sphagnum moss and ferns from 7000 to 4000 YBP is a relatively dry sedge-grass meadow (Fall 1985). Data from the same study suggest an increase in extent of lodgepole pine in the last 2500 years in response to climatic drying and cooling as the spruce-fir forest retreated to higher elevations.

Soil study of a fen along the lower Sand Lake Road, Medicine Bow National Forest (Reider 1983) indicated that soil and climate were not in equilibrium since glacial retreat because of changing paleoenvironments and oscillations of lower timberline since the end of the Pleistocene. Data suggest that soil development began under forest vegetation after retreat of the glaciers, a grassland environment occupied the area during the Altithermal, and forest returned after about 3500 years BP at the end of the Altithermal. This is indicated by an erosional soil unconformity which separates Pleistocene and Altithermal soils from soils formed since the Altithermal (Reider 1983).

Recent studies of soil-plant relationships indicate that there are substantial forest site productivity differences among soils derived from glacial till, from Sherman granite, from mafic rocks and from paleosols (McCahon 1990; McCahon and Munn 1991a; McCahon and Munn 1991b; Kim 1993; Weidler 1995). Considerable variablity in the capability of a site to support particular species or production levels is due to interactions of sediment transport from melting glaciers, parent material, and climate.

Habeck (1987) suggests that the modern Rocky Mountain flora is not in equilibrium with present day environmental conditions, but rather is shifting and adjusting to geographic dislocations associated with Post-Pleistocene climatic alterations. Natural disturbances as well as changes due to human actions such as species introductions, grazing, fire ignitions and suppression, weather modification efforts, timber harvest, road construction, hunting, and mining all

impact the behavior of populations and communities. Habeck (1987) suggests that new communities may be developing which will persist under present climatic conditions and trends.

CLIMATE RECONSTRUCTIONS

Climate reconstructions from tree ring data at four locations in the Great Plains (including sites in eastern Wyoming) indicated that the droughts of the 1930s and 1950s were at least equalled by droughts in the mid to late 1750s, early to mid 1820s, mid 1850s to late 1860s, and 1890s. Drought periodicity averaged 58 years in eastern Wyoming (Stockton and Meko 1983.) Tree ring data from the Sierra Nevada Mountains indicate a 125 year periodicity of temperature variation possibly linked to solar activity. This data agrees with known large scale global warm and cold periods in the past 2000 years (Scuderi 1993).

Summer temperature patterns across western North America since 1600 were reconstructed from tree-ring density patterns. Data for the Eastern Rockies/Northern High Plains suggest cool and warm periods since 1600 (Table 4.1. Mock (1991) analyzed records from diaries of Mormon settlers emigrating in 1849. He concluded that the cold, dry summer of 1849 helped to dispell the notion of the Great American Desert originating from Major Stephen Long's 1820 descriptions of apparantly a warm, dry summer.

Table 4.1 Periods of cool and warm summer temperatures in Western North America since 1600 (Briffa and Jones 1992)

Cooler	Warmer
1601-1610	1630-1639
1620-1629	1645-1654
1673-1682	1794-1803
1698-1707	1856-1865
1831-1840	1931-1940

Remains of massive logs of Rocky Mountain juniper (*Juniperus scopulorum*) over four feet in diameter breast height (DBH) are found along Sand Creek in the Red Buttes area in the southern corner Laramie Basin, about 20 miles south of Laramie, Wyoming. The oldest log in the area was radiocarbon dated at about 5600 years. Wells (1970a, 1970b) suggests that the area was occupied by a juniper woodland during the Altithermal which was not only warmer, but wetter. He suggested that juniper continuously existed in the southwestern corner of the Laramie Basin for at least 2300 years, except for the past 200 years. Now the juniper population has declined to imminent extinction. Wells suggests that the

reproduction success rate of the junipers gradually declined as the climate became drier, while established individuals succumbed at different times. In 1970 there were only three surviving individuals. Pack rat middens in the area indicate very little change in floristic composition over the past 4000 years with the exception of the demise of the juniper and the loss of ponderosa pine from the valley floor. Ellitt-Fisk et al. (1983) agree that Holocene climate change was sufficient to trigger death of conifers in low elevation sites, but disagree that a woodland occupied the floor of the Laramie Basin. Rather, they suggest that more numerous individual junipers and ponderosa pines occupied sandstone outcrops in the past.

The modern Arizona Monsoon brings summer thunderstorms and several inches of rain in July and August to southwestern Colorado and areas east of the mountains and south of the Palmer Divide in Central Colorado. Wells (1970a) suggested that the Arizona Monsoon penetrated further north during the Altithermal, contributing significant summer moisture to ecosystems in southeastern Wyoming and enabling the development of coniferous woodland with juniper and ponderosa pine in the Laramie Basin. A similar hypothesis regarding the summer monsoon boundary was suggested by Mitchell (1976) and Neilson and Wullstein (1983). A more northerly penetration of the Arizona Monsoon rains is a possible explanation for the distribution of Gambel oak in Utah (Neilson and Wullstein 1983). Change in climate and loss of the Arizona Monsoon may be a possible explanation for the expansion of sagebrush steppe and alpine tundra over a larger area in the Rocky Mountains due to the retreat of both upper and lower timberline resulting in current cold, dry conditions (Fall 1985).

The foregoing discussion suggests that during and since the Altithermal period there have been variations in: 1) upper timberline, 2) the extent of lodgepole pine and Engelmann spruce-subalpine fir forest, 3) lower timberline woodlands with juniper and ponderosa pine, and 4) in grassland and sagebrush steppe. The climatic trend toward colder and drier conditions in the Central Rocky Mountains in the past 3500 to 4000 years appears to have induced a number of changes in vegetation. These are: 1) upper timberline became lower, 2) alpine tundra covered more area, 3) spruce-fir forest was restricted to a narrower zone at higher elevations (presently about 9000 to 10,500 feet on the MBNF), 4) lodgepole pine became the predominant species at lower elevations because of its tolerance of cold dry conditions and ability to recolonize sites after catastrophic fire disturbance, 5) lower elevation juniper woodlands and ponderosa pine savanna were replaced by sagebrush steppe or grassland, and 6) mesic species such as Douglas fir, or species requiring warm microclimates, such as Gambel Oak, were restricted to favorable microclimate sites.

THE PRE-1800 HISTORICAL PERIOD

There is little evidence of human use of the mountains of southeastern Wyoming during the Altithermal (7000-4000 YBP). Only small sites are known from 5000 to 500 years YBP). The area around Sand Lake was used by Paleoindians (Deana Wood personal communication). The MBNF is not well-studied archaeologically and more sites may be discovered in the future.

Impacts of Native Americans in the period 1600 to 1800 on mountain ecosystems in the MBNF appear to be rather minimal, especially at high elevations of the Medicine Bow and Sierra Madre ranges. The harsh climate of southern Wyoming, with summer heat and drought at low elevations, and heavy winter snows in the northern Medicine Bow and most of the Sierra Madre Mountains limited human activities. Forests provided good cover for large predators such as grizzly bears and mountain lions and furnished little food for Native Americans and their horses compared to the plains.

The southern end of the Laramie Mountains, the canyons, and the Sherman Mountains were accessible from the Great Plains. Parkman's accounts of the passage of Indians through the mountains, use of lodgepole pine at lower elevations, use of sacred sites accessible from the plains, plus archaeological evidence (Grasso et al. 1981; Fawcett and Francis 1981) suggest that Native American impacts affecting large landscape areas were minor compared to effects of new immigrants after 1860. Indian-caused fires may have impacted edges of all the ranges in the southern Laramie Mountains and Sherman Mountains, but there is no direct evidence one way or the other. Indian-caused fires in high elevations and rugged areas are less likely.

The pre-1800 period was before accelerated change caused by use of natural resources by non-Indian immigrants, although some trappers were likely in the area between 1750 and 1800. Effects of commercial trapping on beaver populations from this time period are not known. Effects of Native Americans on resources of the MBNF are not well known, but are thought to be rather minimal, localized, and mainly at lower elevations.

The oldest ponderosa pines in the Laramie Peak area originated about 1600 and are near a maximum for their natural life span. Tree ages for individual old trees in the Sherman Hills are unknown, but most trees there are less than 150 years old based on Stage II stand age estimates. Lightning ignition rates for these two areas are much higher than for the Sherman Mountains and north Laramie Mountains (Appendix 15). Surface fires are believed to be an important ecological factor in these areas, but no data is currently available from fire scar studies.

Old trees in spruce-fir forests at high elevation date from the early 1600s in the Medicine Bow Mountains are 250 to 400 years old in 1995, indicate that there were large areas of maturing to mature forest (50 to 200 years old) at high elevations by 1800. High elevation fires (over 9500 feet) appear to be very infrequent. Forests may have continuously existed in some high elevation areas for many centuries before 1800. Individual trees are known to be over 700 years old (Earle 1993).

Stand ages have not been measured in wilderness areas of the Sierra Madre Mountains. Most areas which have known stand ages burned during the 1800s. Lodgepole pine ecosystems at lower elevations (~8000-9500 feet) in these two mountain ranges were more likely to have catastrophic disturbance from fire caused by lightning or humans, but the lightning ignition rate was likely very low (see Appendix 15 and discussion in Chapter 6) and disturbance patch size is unknown. Interactions of population behavior and disturbance are not well understood. Lodgepole pine is usually succeeded by subalpine fir and Engelmann spruce, but some areas appear to have persistent lodgpole pine forest with trees 300-350 years old (Three-Mile area). Spruce - fir succession may not occur here because of soil and climate conditions.

THE 1800-1849 HISTORICAL PERIOD

Southern Wyoming was included in the Louisiana Purchase of 1803. The Western Great Plains and Laramie Plains were frequented by nomadic Indians of the Northern Arapahoe, Northern Cheyenne, Ogalala Sioux, and other tribes. Utes and eastern Shoshone lived west of the Sierra Madre (Thybony et al. 1986). From the late 1700s until about the middle of the century fur trappers, adventurers, government explorers, and sportsmen-hunters were the major groups of new inhabitants (Larson 1978). There are written accounts describing the Laramie Mountains and Sherman Hills because these areas were adjacent to the Great Plains and accessible without major road-building, but no descriptions were found of the Medicine Bow and Sierra Madre areas. Travelers apparantly skirted these mountains on their way to trapping rendezvous on the Green River, or to the Oregon country (Townsend 1978).

Timber resources in localized areas were used to build cabins and forts. Wood from the east side of the Laramie Mountains was used to build Sublette's Trading Post (1834) and later, Fort Laramie. Small quantities of livestock grazed meadows. Except for the enormous fire in the Battle Creek Valley of the southwestern Sierra Madre Mountains, purportedly as a result of the conflict between Henry Fraeb and other fur trappers and Indians in 1841, no records of major impacts to terrestrial ecosystems on the Medicine Bow National Forest by settlers, trappers, or explorers prior to 1850 were found.

Native Americans generally continued historic lifestyles and relationships to the landscape during this time. There was some depletion in their numbers due to losses from smallpox and other new diseases.

Pre-European beaver populations in North America have been estimated to be 60-400 million animals or the equivalent of 10-60 animals per mile of stream and river (Naiman et al. 1986). Present-day estimates of North American beaver populations range from 6-12 million, a fraction of the original numbers (Naiman et al. 1986). The MBNF is believed to have had large beaver populations prior to the development of the fur trade. However, by the late 1830s, populations had been significantly reduced by trapping, and the fur trade began to dwindle. Some beaver trapping continued throughout the remainder of the 1800s. By the early 1900s, beaver populations were essentially eliminated except for scattered colonies in inaccessible areas.

EARLY ACCOUNTS

Two trails, used by Indians, trappers, and emigrants crossed the Laramie Plains. The Laramie Pass Trail from Sublette's trading post came through Sybille (Sibille) Canyon and crossed the Laramie Plains to the base of the Medicine Bow Mountains at Elk Mountain. The Crow Creek Pass trail was an entrance from the South Platte River drainage, across the Sherman Mountains to the Park Pass Trail which traversed the southern Medicine Bow Mountains in Wyoming into North Park (Figure 4.2).

John Charles Fremont came into the Laramie Plains and up Crow Creek via the Sherman Mountains on the way to Oregon in 1842. Maps of the time (Jackson 1970) are shown in Figures 4.1-4.3. These maps show some name differences from today - the Sierra Madre Mountains were called the New Park Mountains, North Park was called New Park, and the Laramie Mountains were the Black Hills. Eleven species of plants from the "Black Hills" or "Black hills of the Platte" (Laramie Mountains and environs) were collected in this expedition (Torrey 1845).

Bostonian Francis Parkman and a friend spent three weeks in the summer of 1846 with the Sioux Indians in the Laramie Mountains, in the Laramie Plains, and along the Laramie River and its tributaries (Wade 1939; Parkman 1950). Fremont and Parkman had very different impressions of the area, even though they both visited during the summer months.

Fremont (traveling from the Sherman Mountains, across the Laramie Plains to the northwest, near Elk Mountain):

> August 1 (1842)... We travelled to-day over a plain, or open rolling country, at the foot of the Medicine Bow mountain; ...the beautiful plants of yesterday reappeared occasionally; flax in bloom occurred during the morning, and esparcette in luxuriant abundance was characteristic of the stony gound in the afternoon... The Laramie Peak was in sight this afternoon. August 2... The neighboring mountain is thickly studded with pines intermingled with the brighter foliage of aspens, and occasional spots like lawns between the patches of snow among the pines, and here and there, on the heights. Our route below lay over a comparative plain, covered with the same brilliant vegetation, and the day was clear and pleasantly cool... We halted at noon on the most western fork of the Laramie River—a handsome stream about sixty feet wide and two feet deep with clear water and a swift current, over a bed composed entirely of boulders or roll stones... In the afternoon we took our way directly across the spurs from the point of the mountain where we had several ridges to cross; and although the road was not rendered bad by the nature of the ground; it was made extremely rough by the stiff, tough bushes of *Artemisia tridentata*, in this country commonly called sage. This shrub now began to make its appearance in compact fields; and we were about to quit for a long time this country of excellent pasturage of brilliant flowers (Fremont 1845).

Parkman—entering the Laramie Plains from the Laramie Mountains (then called the Black Hills) in July, 1846:

> As we gained the top of the gap, the prospect beyond began to disclose itself. First we saw a long, dark line of ragged clouds upon the horizon, while above them rose the peaks of the Medicine Bow Range, the vanguard of the Rocky Mountains; then little by little the plain came into view, a vast green uniformity, forlorn and tenantless, though Laramie Creek glistened in a wavy line over its surface, without a bush or tree on its banks... (Parkman 1950, page 133).

Parkman kept notes which formed the basis for his book *The Oregon Trail*, first published in 1849. This book is mostly about the Indians and the land and provides excellent descriptions of the Laramie Mountains.

In 1978, Mr. Charles Neal, former soil scientist with the Medicine Bow National Forest, retraced a portion of Parkman's travels through the Laramie Mountains using the landscape descriptions in Parkman's journals. According to Neal, Parkman travelled northward to the vicinty of LaBonte Creek and the North Platte

River and then returned to a campsite north of Wheatland. He then followed the Indians for three weeks during July and August up the North Laramie River west of Wheatland, overland to Fletcher Park, south-southwest to a few miles below the present site of Wheatland Reservoir, westward across the Laramie Plains, and through the Rock River area to the north slopes of Elk Mountain. The return trip passed the present site of Rock River, went northeast to the Garrett area and the Cow Creek Mountains, and then back to the Wheatland area though the North Laramie River Canyon (Neal 1986).

The following excerpts are from Parkman's accounts:

> ...We resumed our journey, traversing a forlorn and dreary monotony of sun-scorched plains, where no living thing appeared save here and there an antelope flying before us like the wind. When noon came we saw an unwonted and welcome sight; a fine growth of trees, marking the course of a little stream called Horseshoe Creek. They stood wide asunder, spreading a thick canopy of leaves above a surface of rich, tall grass. The stream ran swiftly, as clear as crystal through the bosom of the wood, sparkling over its bed of white sand, and darkening again as it entered a deep cavern of foliage (page 116) (Horseshoe Creek, Laramie Mountains).
>
> ...just before sunset we reached another stream, called Bitter Cottonwood Creek. A thick growth of bushes and old storm-beaten trees grew at intervals along its banks... The little stream was clear and swift, and ran musically over its white sands (page 121) (Laramie Mountains) .
>
> All around, the black crags, sharp as needles at the top, stood baking in the sun, without tree or bush or blade of grass to cover their nakedness. The whole scene seemed parched with a pitiless, insufferable heat ... we found a black rock, overarched by a cool, green canopy. An icy stream was pouring from its side into a wide basin of white sand, when it had no visible outlet but filtered into the soil below... Other visitors had been there before us. All around in the soft soil were the footprints of elk, deer, and the Rocky Mountain sheep; and the grizzly bear too had left the recent prints of this broad foot, with its frightful array of claws. Among these mountains was his home (page 128) (Canyon area southwest of Laramie Peak).

> In half an hour we were free of the mountains. There was a plain before us, totally barren and thickly populated in many parts with prairie dogs (page 129) (Mountain park).
>
> Turning sharply to the left, we entered a wide defile of the mountains, down the bottom of which a brook came winding, lined with tall grass and dense copses, amid which were hidden many beaver dams and lodges (page 171) (Laramie Mountains).
>
> We passed mountain after mountain, and valley after valley; we explored deep ravines; yet ... no game could be found. So, in the absence of better, we resolved to go out into the plains and look for an antelope. With this view, we began to pass down a narrow valley, the bottom of which was covered with the stiff wild-sage bushes, and marked with deep paths, made by the buffalo, who for some inexplicable reason, are accustomed to penetrate, in their long, grave processions, deep among the gorges of these sterile mountains (page 176) (Laramie Mountains).
>
> That morning's march was one not to be forgotten. It lead us through a sublime waste, a wilderness of mountains and pine forests, over which the spirit of loneliness and silence seemed brooding. Above and below, little could be seen but the dark, green foliage. It overspread the valleys and enveloped the mountains; from the black rocks that crowned their summits to the streams that circled round their base (page 185) (Laramie Mountains).

Parkman mentions fires on the east side of the Laramie Mountains:

> We were on the eastern descent of the mountain ... The mountains before us were on fire, and had been so for weeks. The view in front of us was obscured by a vast, dim sea of smoke, while on either hand rose the tall cliffs, bearing aloft their crests of pines, and the sharp pinnacles and broken ridges of the mountains beyond were faintly traceable as through a veil... We passed over a burnt tract where the ground was hot beneath the horses' feet and between the blazing sides of two mountains (page 188) (Laramie Mountains).

Parkman mentions abundant game including bison on the plains—grouse, lion, wolf, marten, black bear, grizzly bear, fox, and coyote. In 1846, numerous fur

trappers were in the mountains. His accounts of the Laramie Mountains and others in the period before 1850 indicate that game was abundant (Thybony et al. 1986). It appears that the mountains were well-forested. It is not possible to tell if the fires referred to above were canopy fires, surface fires, or some combination.

THE 1850-1902 HISTORICAL PERIOD

This was the period of accelerated change to vegetation and animal populations due to the arrival of European culture in the western United States. Beginning about 1849, thousands of emigrants passed through the surrounding plains on the Overland Trail through the Laramie Plains, on the Oregon Trail through the east edge of the Laramie Mountains, and along the west side of the Sierra Madre Mountains. Conflicts with Indians in the early 1860s prompted the establishment of Fort Sanders (near Laramie, Wyoming) and Fort Fetterman (near Douglas, Wyoming). Wealthy sportsmen-hunters began to hunt big game in the late 1860s. By the 1890s market hunting had eliminated or drastically reduced bison, elk, deer, antelope, and bighorn sheep populations (Dary 1986). Homesteaders began farm and ranch operations mostly around the edges of what is now the MBNF, except in the Laramie Mountains where ranches were established in valleys within the mountain areas.

Miners congregated in the southern Medicine Bow Mountains, Sierra Madre, and in scattered places in the Laramie Mountains after 1850. The location of the mountains, adjacent to the Great Plains and within the North Platte River Basin, made the timber resources especially accessible for telegraph poles, railroad ties, and building materials for forts on the plains. Some activities which affected terrestrial ecosystems during this period included logging, hunting, livestock grazing, poisoning and shooting of predators, and man-caused fires. Tie drives, water diversions, hydraulic mining, beaver removal, and fish introductions affected riparian and aquatic ecosystems.

TERRESTRIAL ECOSYSTEMS

Forests

Hayden travelled up the Chugwater River into the Sherman Mountains and then to Cottonwood Park near Laramie Peak and LaBonte Canyon in 1869. Most of his descriptions are geological, but he provided some information on vegetation, especially if it had economic value.

By 1869 the Union Pacific Railroad had been in operation for several years, and the Laramie Plains had settlers. Of the LaBonte and Horseshoe Creek headwaters, Hayden said:

> The pine forests in the mountains at the sources of the Horseshoe and the LaBonte are more dense and the timber larger, than in any other portion of the range that we have seen. Great abundance of ties for railroad purposes could be procured. Our camp in the valley of the LaBonte was a pleasant one; a fine luxuriant growth of grass covered the immediate bottoms of the creek, and our animals found excellent grazing on the uplands also. The creek is bordered with bitter and sweet cottonwood, box elder and large tree willows to a considerable extent (page 20) (Hayden 1871.

The atmosphere was very smokey on August 16, 1869, as the Hayden party proceeded from LaBonte Creek to Fort Fetterman. Crossing the Laramie Plains on the way west, Hayden described beaver dams flooding areas half a mile wide on Medicine Bow Creek. Dense pines rimmed Rock Creek where it emerges from the gorge north of the Snowy Range. Thousands of cattle grazed on upland plains above broad meadows where hundreds of tons of hay were prepared each year in the valley of the Little Laramie River:

> It is probable that this region is destined to become celebrated as one of the finest pastoral districts in America (page 80) (Hayden 1871).

Hayden's words were prophetic as he described the forests of the Medicine Bow Mountains from a vantage point along the Big Laramie River:

> I would again remark that the pine forests of these mountains must at some period be an object of earnest pursuit. Two years ago the mountain sides were full of tie cutters who cut and floated hundreds of thousands of ties down the mountain streams, fifty to one hundred miles, to the Union Pacific, whence they were transported by railroad to any desired point (page 126) (Hayden 1871).

> During the summer of 1868 an excitement was created at Laramie City by the supposed discovery of rich placer mines far up in the mountains near the Snowy Ranges to the southwest of the plains. A large party was formed at Fort Sanders, directed by Generals Gibbon and Potter of the United States Army, and accompanied by Professor James Hall of New York, to visit the region and ascertain the truth of the reports... After passing through dense pine forests for nearly ten miles we suddenly emerged into one of these park-like areas. Just in the edge of the forest which skirted it were banks of snow six feet deep, compact like a glacier, and within a few feet were multitudes of flowers, and even the

> common strawberry seemed to flourish. These mountains are full of little streams of the purest water, and for six months of the year good pasturage for stock could be found... Not only in the more lofty ranges, but also in the lower mountains, are large forests of pine timber which will eventually become of great value to this country. Vast quantities of this pine in the form of railroad ties are floated down the stream from the mountains along the southern side of the Laramie Plains. The Big and Little Laramie, Rock Creek, and Medicine Bow River, with their branches, here literally filled with ties at one time, and I was informed that in the season of high water, they can be taken to the railroad from the mountains, after being cut and placed in the water, at the rate of from one to three cents each. These are important facts, inasmuch as they show the ease with which these vast bodies of timber may be brought to the plains below and converted into lumber, should the future settlement of the country demand it (pages 128-129) (Hayden 1871).

Much of the wood resource in the Sherman Mountains was depleted or destroyed by fire before 1870. Tie hacking did not occur in the Sherman Mountains, but wood was used for construction and to fuel steam engines.

In 1888, Edgar T. Ensign, Forest Commissioner of Colorado, reported on Albany and Carbon Counties (Ensign 1888). He described large tracts of good sawtimber between Fort Fetterman and the LaBonte and Horseshoe Creeks in the Laramie Mountains. Lodgepole pine was the predominant forest tree in the Sherman Mountains. He estimated that about one fourth of the entire forest area in Albany County was good timber and noted that regeneration soon followed after disturbance on northern (north-facing) slopes. For the Medicine Bow and Sierra Madre Mountains in Carbon County, he noted that lodgepole pine, 2 to 14 inches in diameter, was the predominant species. He described six-foot diameter trunks of spruce at high elevations and aspen two feet in diameter along French Creek.

Fernow (1888) mentions the central Laramie Mountains, Medicine Bow Mountains and Sierra Madre Mountains as areas of good timber, but that forest fires were frequent and destructive. Statewide, 83,780 acres were burned in 1880. Fernow pointed out that although penalties were prescribed for willful or careless firing of woods, marshes, or prairie, there was no one to enforce the laws and guilty parties were rarely apprehended.

Other reports during the next decade underscored the problems with forest fires. In 1890 the Governor of the new state of Wyoming recommended Federal legislation be created for the leasing of timbered lands, under restriction, and that regulations were needed.

> He (the Governor) gives as his opinion that the amount of timber used (by settlers and others) does not reach 5 per cent of the total amount consumed by forest fires. He believes it to be important that Congress should set aside large forest reservations at the sources of great rivers, and reserve them from disposal under existing laws (House of Representatives 1890).

A similar assessment was submitted in 1891.

In 1891 the Forest Reserve Act enabled creation of Forest Reserves by Presidential Proclamation. By 1897 an Act to prevent forest fires on the public domain was passed and 19 forest reserves had been created. Yellowstone National Park Timber Reserve was the only one in Wyoming (USDI 1897). Gifford Pinchot reported in 1899 that "A special study of reforestation on burnt land is in progress in the Medicine Bow Mountains of Colorado, and promises most interesting results" (page 98) (Pinchot 1899).

Grasslands and Shrublands

Mormon emigrants were among the first to drive breeding cattle into Wyoming in the late 1840s. Wyoming was very attractive to those interested in raising sheep and cattle because of the low land prices and free grass and water. The first large herd of cattle was wintered in an area near the town of Chugwater, Wyoming in 1852. By the mid-1880s, the number of cattle in southeast Wyoming created pervasive overgrazing problems.

Land surveys were conducted from Elk Mountain to the Laramie Plains and the Sherman Mountains in 1872-73. In 1874 the Surveyor General's office reported a rapid increase in cattle and sheep herds in the valleys of Crow Creek and Lodgepole Creek in the Sherman Mountains and east of the Laramie Mountains. Forty-four hundred head of cattle were shipped east from Cheyenne on the railroad (Department of the Interior 1874).

Livestock grazing was widespread after about 1870. Wyoming did not become a state until 1890, and by then much of the change from cattle and sheep grazing on grasslands and shrublands had occurred. Early Forest Service reports on range condition describe overuse, poor range condition, and erosion caused from livestock (Blackhall 1909; Mullison 1909). After the turn of the century, most high-quality low elevation lands were used for hay production, and increased grazing pressure was put on mountain grasslands, alpine areas, and mountain riparian areas.

Wildlife

An excerpt from the 1909 *Report for the Forest Atlas*, when compared to current information on animal biological diversity, indicates not only extirpations (wolverine, fisher, grizzly bear, gray wolf, and otter), animals with diminished populations (lynx, bobcat, mountain lion, black bear, swift fox, ans ringtail), but also less genetic diversity (cinnamon bear, cross-bar fox, and silver grey fox).

> As late as 1880 the Medicine Bow Mountains, now included in the Cheyenne National Forest, also the whole of North Park and Upper Platte Valley, were wonderfully well stocked with game, seemingly in inexhaustible quantities in the order named: antelope first, then Wapiti or elk, deer and Big Horn, or mountain sheep, abounded. It was a veritable hunters paradise. There were also a few bison, or mountain buffalo in the rugged and almost inaccessible portions of the mountains, The range grizzly, cinnamon and black bear, the wolverine, carcajou or indian devil, lynx, wild cat [bobcat], mountain lion, grey wolf, mountain wolf or as locally called, coyote, and the fur bearers consisting of the beaver, otter, mink, skunk, muskrat, badger, pine marten, and a small species of the raccoon [ringtail], the swift or grey fox, the red fox, the cross-bar fox, and an occasional silver grey fox, were plenty or at least common. All these can still be found on the Cheyenne National Forest (1909), but in greatly diminished numbers with the exception of the buffalo, antelope and the Wapiti which are nearly or quite extinct (Mullison 1909), [ ] added for interpretation.

AQUATIC AND RIPARIAN ECOSYSTEMS

Stream Channels and Tie Driving

Tie hacking is the preparation of hewn railroad ties mainly from lodgepole pine forests. Tie driving is the transport of the hewn ties down streams and rivers. Ties were removed from the North Platte River at Fort Fred Steele (located where I-25 now crosses the North Platte River). Tie hacking and tie driving affected large areas of both the Medicine Bow and Sierra Madre Mountains from 1867 to 1940.

The Pacific Railway Act was passed in 1864 at the end of the Civil War. Soon there was a large market for railroad ties. The MBNF had many tributaries on the North Platte down which ties could be floated to build and maintain the Union Pacific railroad built across the Great Plains and Great Basin. At least three timber companies contracted with the Union Pacific railroad to supply ties. They

were Gilman and Carter; Paxton and Turner; and Sprague, Davis, and Company (Thybony et al. 1986).

The first tie camps were established in 1868. By 1870, there were camps on every stream on the east side of the Forest and in Douglas Creek and French Creek on the west side (Mullison and Lovejoy 1909). Between 1868 and 1910 alone, the MBNF yielded an estimated 320 million board feet of forest products, primarily ties, with the vast majority of this material being transported by streams (Mullison and Lovejoy 1909).

The "tie drives," varied in size and duration and were heavily dependent on the volume of spring runoff in the streams (Photos H3-H6, H9, H10). Between 1898 and 1902, 1.4 million ties and 300,000 mine props (52 MBF of timber) were transported down the Medicine Bow River and Rock Creek (Medicine Bow Collection). The last drive on the MBNF took place on Douglas Creek in the spring of 1940 (Table 4.2 and Figure 4.4).

Young et al. (1994) provides the following description of the tie-driving process:

> Tie drives culminated activities that began the previous year. Beginning in mid-summer and continuing through winter, workers cut conifers, primarily lodgepole pine from 28 to cm dbh (Mullison and Lovejoy 1909, Anonymous, 1913), into 2-m railroad ties that were decked adjacent to the streams. Prior to the drive, stream channels were often cleared of obstructions to flow e.g., debris jams and boulders, to reduce the likelihood of jams (Sedell and Duval 1985). For example, a timber sale report suggested that "South Fork of Hog Park Creek can be made drivable...The improvements to be made will consist of blowing outlarge rocks and cutting out jammed windfalls" (Anonymous 1914). Also, a newspaper reported that "The tributary creeks [of the Encampment River] have been cleared of all downed timbers that there will be no obstructions in the stream to prevent the free passage of ties" (Anonymous 1902). At least once, drives were initiated by blasting ice from the channel (Anonymous 1924). The drives themselves also cleared the channel; Lerchon and Beals (1936) stated that "It is the usual practice first to break the lower landings in order to secure a sufficient number of ties to wing out the creek banks, thus artificially straightening the stream and forming a channel through which the ties may pass with the greatest speed and facility."

Despite these precautions, drives frequently resulted in huge jams that were either dislodged by blasting or by removing individual pieces (Bruce 1959).

Table 4.2 **Known tie-driven streams on the Medicine Bow National Forest in southeastern Wyoming. Tributaries to larger streams are denoted by successive indentations. Data are modified from Young et al. (1994).**

Stream	Year(s) driven
SIERRA MADRE MOUNTAINS	
Big Creek	1869-1921
Brady Creek	1914
Olson Creek	1914
Miller Creek	1914
Dudley Creek	1915
East Fork Encampment River	1902-1914
Coon Creek	1902-1914
Damifino Creek	1902-1914
Hog Park Creek	1914-1924
South Fork Hog Park Creek	1915
West Fork Hog Park Creek	1915
North Fork Encampment River	1868, 1902-1923
South Fork Encampment River	1868-?
Encampment River	1903-1924
MEDICINE BOW MOUNTAINS	
French Creek	1870-1906
South French Creek	1870-1906
Middle French Creek	1901-?
North French Creek	1880-1905
North Cottonwood Creek	?-1916
Brush Creek	1874-1906
North Brush Creek	1880-1902
South Brush Creek	1880-1905
Woods Creek	1905
Barrett Creek	1876-1902
South Fork Barrett Creek	1902-1905
Lake Creek	1923
Devil's Gate Creek	?-1904-?

Table 4.2 continued

Stream	Year(s) driven
MEDICINE BOW MOUNTAINS	
Savage Run Creek	?-1916
Mullen Creek	1899-?
Pass Creek	1870-1903
East Fork Pass Creek	?
Medicine Bow River	1872-1907
Turpin Creek	1876-1907
East Fork Medicine Bow River	?-1879-1907
Libby Creek	1869
Fourmile Creek	?-1880
Rock Creek	1868-1894-?
South Fork Rock Creek	?
Trail Creek	?
North Fork Rock Creek	1870-?
Deep Creek	?
Carlson Creek	1890-?
Douglas Creek	1870-1940
Elk Creek	?
Dave Creek	?
Horse Creek	1928
Keystone Creek	1928
White Swan Creek	1917
Muddy Creek	1924-1928
Indian Creek	1927
Spring Creek	1919
Smith North Creek	?
Big Laramie River	1868-1940
Stuck Creek	1880-1934
Fox Creek	1885
Little Laramie River	?-1870
South Fork Little Laramie	?
Middle Fork Little Laramie	?
North Fork Little Laramie	?

Tie drives were conducted during high spring flows from melting snow. Typically, the decks were dislodged by hand directly into the streams (Thybony et al. 1986). Because extremely high flows would scatter ties throughout the floodplain, the drives usually began before or after the peak streamflows on the rivers and larger streams. To facilitate drives on smaller streams, surge dams were constructed to store and release water as needed (Thybony et al. 1986). On very small or very steep streams, workers built flumes to transport ties to driveable streams (Rosenberg 1984).

Tie drives radically changed stream channel configuration, stability, and the integrity of aquatic habitat. Many streams still show post-tie drive channel effects. The effect of tie drives on streams in the Medicine Bow National Forest was examined by Young et al. (1994). They found that tie drives reduced the complexity of stream channel, both directly and through the removal of large organic debris and boulders. The drives widened some channels as many as five to seven (Wesche 1987), which led to increased riffle habitat. Young also documented a significant loss of pool volume, reduced sediment and organic material storage, decreased channel roughness, and fewer side channel habitats for adult and juvenile fish.

A secondary effect of tie drives was the widespread removal of trees in riparian areas. In unimpacted sites, Young et al. (1989) observed old growth forest of both lodgepole pine and spruce-fir with a wide variety of age classes. In contrast, riparian zones associated with tie-driven streams contained generally even-aged stands of early successional species (lodgepole pine) and lacked large standing or dead trees. Young hypothesized that there had been a steady contribution of large trees to streams prior to tie hacking and tie driving. The large trees present in tie-driven channels had been transported from upstream areas away from the impacted area or were residuals from the pre-impact stand. Later studies conducted on the forest helped to substantiate this hypothesis (Young et al., 1994).

Hydraulic Mining and Dredging

Gold was discovered in the Medicine Bow Mountains in 1856 (Thybony et al. 1986). By 1868, mining districts were found throughout the entire Douglas Creek drainage. Mines were also established on the Middle Fork of the Laramie River, the Laramie River, the headwaters of the North Platte River (Medicine Bow Mountains), Battle Creek (Sierra Madre Mountains), and LaPrele and LaBonte Creeks (Laramie Mountains). Methods of mineral extraction included panning, sluice boxes, rocker boxes, dredges, hydraulic mining, and hard rock mining (Photos H1, H2). Minerals extracted included gold, copper, and platinum.

Hydraulic mining and/or the dredging of stream bottoms was most prevalent in the Douglas Creek and Spring Creek watersheds. The mainstem of Douglas Creek was dredged and placer mined in several locations (Photos H3-6). Floodplains and riparian vegetation were drastically altered as a result of these activities. Large amounts of sediment were released, riparian vegetation was destroyed, and aquatic habitat throughout the watershed was affected. Nugget Creek, a tributary to Spring Creek, was similarly impacted by dredging (Photos H7, H8).

Water Quality

The Ferris-Haggerty copper mine (Sierra Madre) was abandoned after 1903. The mine shaft intersects the water table allowing ground water to absorb high concentrations of copper as it flows into the shaft. The contaminated water flows from the mine shaft into a small tributary which discharges into Haggerty Creek. The stream is biologically sterile for several miles downstream until the contaminated water is diluted by flow from the west fork of Battle Creek The Wyoming Department of Environmental Quality has identified the Ferris-Haggerty mine as the "most severely impacted stream in Wyoming" from point source heavy metal pollution. The problem is currently under study (Gumtow et al. 1994, page 296).

Water Diversions

Water diversions for irrigation occurred as early as 1851 in the Laramie River drainage. Many of the early ditches were developed along the Laramie River and its tributaries. The first large canal in the basin was the Pioneer canal, completed in 1879. The canal diverted water from the Laramie River for the irrigation in the Laramie Basin several miles away. This canal is still in operation in 1995.

Water development in the mountains, consisting of small canals that diverted water to irrigate bottomlands, began around 1880 (various documents, Medicine Bow Collection). Several water diversion projects were constructed, primarily in the Douglas Creek and Little Laramie River drainages. By 1915, virtually all the water from the Sierra Madre Mountains, except for the North Platte River, was appropriated for private irrigation uses (Blackhall 1915). Water was also diverted to create supplies for hydraulic mining, sluice boxes and flumes to transport railroad ties from uplands to creeks in canyon bottoms (Wood 1995).

Water development on and off the National Forest caused changes outside the National Forest Boundary. Water from a forested watershed would be removed at or near the forest boundary for use on the open plains. Streams like the lower Laramie River experienced a significant reduction from historic streamflows as a result. This condition still exists on many of the streams immediately outside the Medicine Bow National Forest boundary.

Beaver Populations and Riparian Areas

During this time, trapping of beaver decreased but tie driving annually destroyed beaver dams on many streams. By the end of the century beaver populations were depleted in some areas (Sherman Mountains), status of beaver in other areas is not known.

Fish Introductions

About 1874, the first trout (Colorado River cutthroat trout) were transported from west of the Continental Divide and stocked in the North Platte River drainage (Medicine Bow Collection). Early attempts at fish stockings were not widespread and were generally unsuccessful (Medicine Bow Collection).

Introduction of non-native fish species began in 1880 when the first State Fish Commissioner, Henry B. Rumsey, had 50,000 young rainbow trout shipped in barrels from Wisconsin and planted in tributaries to the North Platte River (Simon 1940). The following year streams in Albany, Carbon, and Laramie counties were stocked. However, the precise release locations and species of fish released are not known. From 1882 to 1883, "salmon trout," brook trout, black bass, walleye, pike, and carp were planted in the Cheyenne-Laramie area (Wiley 1993).

The first Wyoming Hatchery was built at Soldier Springs in Albany County in 1883. This hatchery produced approximately 200,000 brook trout annually, The trout were successfully stocked in the Laramie, North Platte, Green, and Bear Rivers (Miller 1890). That same year "native" trout were planted in the headwaters of the South Platte River in Wyoming, the north Laramie River, the Big Laramie River, and several tributaries to the North Platte River near Saratoga, Wyoming. The term "native" implies cutthrout trout, however the exact subspecies is unknown. In 1882, the new Fish Commissioner, T.W. Quinn, successfully transported trout several hundreds of miles thus spreading "native" trout to other drainages in Wyoming (Barkwell 1883).

Three additional State Fish Hatcheries were operational by 1890 (Wiley 1993). By the late 1890s, dozens of streams in central and southeast Wyoming were stocked with various species of trout. Arctic grayling were also stocked in the headwaters of the North Platte River (Schnitger 1898). It was during this time that Fish Commissioner Gustave Schnitger recognized the futility of stocking warm-water species in Wyoming's cold lakes and streams. Such practices were disallowed during his term in office which ended in 1898 (Simon 1951). A summary by year and watershed of the fish species stocked within the North Platte, South Platte, and Colorado River drainages in southeastern Wyoming is in Table 4.3.

Table 4.3 **Stocking of non-native fish into the North Platte, South Platte and Little Snake River drainages of southeastern Wyoming between 1870 and 1950.**

Watershed	1870-1879	1880-1889	1890-1899	1900-1909	1910-1919	1920-1929	1930-1939	1940-1950
Upper North Platte River	CRC	RBT,CUT LLS,BRN	BKT,BRN CUT,RBT AG	BKT	BKT,YCT SH	BRN,CUT BKT,RBT YCT	BKT,CUT RBT	
Rock Creek/ Medicine Bow River		CUT	T		BKT,BRN RBT,CUT	BKT,RBT CUT,YCT LL	BKT,RBT CUT	
Laramie River		BKT,LMB WP,C	BKT,T	BKT	BKT,BRN RBT,CUT LL,YCT SH	BKT,CUT SH,RBT YCT	LL,BKT RBT,CUT	
North Laramie River		CUT	T,LMB		BKT,BRN RBT			
Lodge Pole Creek		BKT,WP C,CUT LMB						
Crow Creek		LMB,BKT WP,C,CUT						
Horse Creek			T					
Dry Creek		BKT,LMB WP,C,CUT	T					
Lower North Platte			CUT	T				
Savery Creek							BKT,CUT RBT,BRN	BKT,CUT RBT,BRN
Battle Creek							CUT	CUT,RBT
North Fork Little Snake River							CUT,BKT	CUT

Table 4.3 concluded

Watershed	1870-1879	1880-1889	1890-1899	1900-1909	1910-1919	1920-1929	1930-1939	1940-1950
Roaring Fork of The Little Snake River							CUT,BKT	BKT
West Branch North Fork Little Snake River							CUT	CUT
Muddy Creek							BKT,CUT	

Legend:

AG - Artic Grayling
BRN - Brown Trout
CRC - Colorado River Cutthroat Trout
LLS - Land-locked Salmon
SH - Steelhead
WP - Walleye Pike
BKT - Brook Trout
C - Carp
LL - Loch Leven
LMB - Large Mouthed Bass
T - Trout(species unknown)
YCT - Yellowstone Cutthroat Trout

THE NATIONAL FOREST ADMINISTRATION PERIOD (1902-1995)

1902 - 1949

Organization of Forest Reserves and National Forests was from about 1897 through the first decade of the 1900s. After National Forest adminstration began, timber cutting was regulated. Most timber harvest was selective cutting of lodgepole pine until the last few years of the 1940s when strip-clear cutting began after World War II. Based on an analysis of stand ages, fire size and frequency decreased suddenly and dramatically.

Some tie-camps and small mining towns became permanent towns or summer recreation centers. During this time period major roads were built in the mountains. Conservation programs for big game were initiated, and poisoning of predators and some small mammals continued. Meat from big game was supplied to soldiers in World War I, but did not result in extirpation of large game as had market hunting in the previous decades. Grazing regulations improved grassland and shrubland condition, but the drought of the 1930s was a major setback to these efforts.

TERRESTRIAL ECOSYSTEMS

Forests

The area now the MBNF in Wyoming was part of three Forest Reserves in the first decade of the 1900s. Forest Reserves in this part of Wyoming were:

The Crow Creek Forest Reserve (1900)
The Medicine Bow Forest Reserve (1902) (Colorado and Wyoming)
The Sierra Madre Forest Reserve (1906) (Colorado and Wyoming)

The Sherman Hills was originally the Cheyenne National Forest and was formed from the Crow Creek Reserve. This area was used for military maneuvers for many years. The portion of the MBNF in the northern Laramie Mountains was added to the MBNF in 1935.

In 1905 a brief report entitled *Medicine Bow Forest Reserve – Wyoming* (author not known) provided a description of the Medicine Bow Mountains (MBNF 1905).

> The forests of the Medicine Bow Reserve are readily divided into two classes, commercial and protective, the former at an altitude of 7,500 feet to 10,000 feet, the latter from 10,000 feet to timberline. The commercial forest is usually a dense stand of

> Lodge Pole Pine... In a virgin forest, unless fire or windfall intervene, the type of the forest is usually changed into a spruce and fir stand. Lodgepole pine is subject to windfall, and any system of management, which does not take this into account, fails to consider a very important factor. It is almost immune from insect attacks. Its value is chiefly as railroad ties. The practice of cutting tie timber only is somewhat pernicious. The size taken is probably during the period of greatest volume growth, young pole stands that need thinning are neglected, also the larger timber is left. Provision will be made as soon as a market is developed to thin the pole patches and dispose of the larger timber... The practability of conservative lumbering in this region has long been demonstrated, it has been culled over for several hundred thousand railroad ties, annually, amounting to millions of board feet, for the past 35 years. The results where fire has been kept out are gratifying in the extreme; several hundred acres are being cut over this year for the second time. Accelerated growth is evident on all trees cut from this class of lands, especially in the smaller diameters, while the reproduction is usually very good. (Medicine Bow National Forest 1905)

In 1906, Frederick Dunlap spent two months assessing dead and mature timber in the Medicine Bow Forest Reserve, Colorado and Wyoming. This was four years after the Cheyenne National Forest (later to become the Medicine Bow National Forest) was organized. The area Dunlap evaluated, inspecting areas from ridges by horseback, extended from Estes Park, Colorado, to the north end of the Medicine Bow Mountains in Wyoming.

Dunlap visited as many major burns as possible. He divided the Medicine Bow Reserve into 14 Districts, nine of which were in Colorado and included what is now Rocky Mountain National Park and the Arapaho-Roosevelt National Forest. About one page of the 27-page report is devoted to the Medicine Bow Mountains of Wyoming.

> All the districts of the Wyoming Division (10-14) are considered together, for here it is not necessary to take each watershed separately, estimating the amount of stumpage, and studying the possible avenues for removal. The timber is accessible as timber goes in this part of the country, and there is a market for any amount of green and dry timber. The Carbon Timber Company is ready to buy all the material offered for sale. This company is operating in the Reserve here, and now has two areas under sale, one of 15,000 acres in the watersheds of Brush and North French Creeks in the northwestern part of the Reserve and one of 55,000

> acres in the Douglas Creek watershed on the east central part of the reserve. In these sales the dry timber is taken with the green at the same price and on the same terms. It is used for railroad ties and mine props.

The following is quoted from the terms of the sale under which 165 mmbf (million board feet) had recently been disposed of in the Douglas Creek area:

> All dead timber sound enough for railroad ties, mining timber, or merchantable lumber of any grade will be cut... and all merchantable dead timber left uncut or not removed from the Forest Reserve after cutting will be paid for at double the contract price. The terms of sale under which this company is operating on French Creek are approximately the same. Clearly there is no need for strengthening the market here (Dunlap 1906).

Tie hacking selectively removed mainly 11-14 inch lodgepole pine. Some spruce was used for ties. Spruce was also used as lumber for such items as doors on railroad cars (Wood 1995). Silvicultural practices under National Forest Administration can be characterized in general as follows: 1) Between 1902 and 1914 contracts called for removal of both live and dead timber, but not over 35% percent sand. Piling and burning of slash was mandatory. 2) Between 1914 and 1922 contracts did not require removal of trees greater than 15 inches DBH, but did require removal of about 35 percent of trees 10-15 inches DBH with piling and burning of slash. 3) After 1922 contracts called also for removal of trees too large for ties (to remove older trees), with at least 45 percent of all trees greater than 10 inches marked. The result was a lot of sawlog material left on the ground because these trees were not used. Piling and burning of slash was required on a percentage of the area. 4) In 1936, only trees were taken from which ties could be made and 65-85 percent of the volume of a stand was permitted for removal. Blowdown problems ensued because so much of the stand was taken.

Fires in areas where slash from timber operations were left, were a major concern for early managers. A dramatic decrease in fire frequency and size after the early 1900s can be attributed to better management practices (especially slash disposal), fire detection, improved access to fire sites, and organized efforts at fire suppression.

A letter written to Supervisor H.C. Hilton in 1921 by former Forest Supervisor P.S. Lovejoy deserves recognition here because it illustrates the situation and attitudes regarding fire in the early days of National Forest Administration. From Ann Arbor Michigan, Nov. 11, 1921:

Ever hear the story of how it (the Bow Peak Lookout) came into being? I'll bet not - and you can't find the full record in the file either.

Old Ranger Mullison, in the country since the Indian days, used to tell about the times when he had seen Indian smoke signals from the Peak, telling hunters where to find the best buffalo herds. He had been on top too, from the Gold Hill side I think - in any case was perfectly sure the peak was accessible and that it would command an enormous territory. He kept urging me to go up and see what could be seen and that something could be done to make it no end useful in spotting fires. That was about 1907-1908.

Remember that, in those days, there were few of us and things were pretty well mixed up. Timber sales work was the big end with grazing next and fires a dreaded incidental. For the whole Bow there were but 20 shovels in the way of fire outfit. Those were at Keystone and somebody had painted the handles with mineral red which rubbed the insides off our hands on the first fire. There was nothing like a lookout in all District II, nor, so far as I ever heard, in any other District.

Mullison and I used to make medicine, evenings, in the old Clubhouse office at 'Togy. Often and Often we came back to fire and the possibility of a lookout on the Peak. In those days most of the fires were spotted first from the valleys. Maybe a rancher would 'phone in' about it and maybe not. Once there was a fire on the head of Savage Run. I was in the North End watching how the snow was going out when I hit Wiants and found a 'phone call in for me, picked up a horse Mullison had dropped off when he went in from the 'Togy side, checked out the USGS topo sheet which I always carried (it had been issued several years before I discovered it by accident) and rode in off the Rambler road, getting to the fire in time to find Mulison taking a nap in his fur coat and the Forest assistant madly fighting an inside fire which was working in an unburned island. Mullison had ridden hard by Sangers ranch. Others had come in via Devil's Gate from Foxpark and Deputy John Stevens from Foxpark via Keystone, all having gotten into to no end of mess because nobody knew where the fire was or how to get to it, just scattering and going it blind. I had come down from Holmes too. This fire had been first seen and reported <u>from Encampment</u>. It took several <u>days</u> to get a decent crew on it.

Stevens had come up Keystone Creek and had crossed within a few hundred yards of Jay's Roost. But he couldn't read a topo map even if he'd had one and never thought to get on top and see what was in sight. Things were like that then, you know.

Well, after that fire I knew better than ever that something real had to be done. I had climbed Jay's Roost and seen for myself what it commanded and sent out word for the boys to locate all the local lookouts they could find. Coughlin found Somber Hill - with its astonishing command of country and got a trail blazed to it.

Meanwhile I was working on the Bow Peak proposition. In the fall of 1908 I got up on top of the range to Brooklyn Lake, with Mullison. Then with Pennock (sheep ranger) I rode from Sheep Lake via Gold Hill to Headquarters Park and the old French Creek Road over which the Gold Hill machinery had been brought from Centennial and, leaving the horses there, we climbed along the ridge to the top above Lookout Lake, which got its name at that time. We rolled rock down into it, some rock-rolling.

Well, there wasn't any question about it then. Had to get that place rigged for a lookout. But how- without money for a man and without communication.

At the Supers meeting that winter I made my talk for lookouts on the peaks and for phones to connect them up. I claimed there should be a real lookout with a phone for every million acres or so - and in time one for every half-million acres - that it would pay. The Super from the Routt then did his best to josh the idea. "These mountain phone lines - huh - they went down every time you needed them. Put a man on a horse and your message got through. Lookouts! Huh! He had a Forest Assistant wished on him too, one of these school men, yunno. About as useful as a singed yellow cat thrown in the crick." I very well remember these kind words because the Supers laughed heartily. I was a schoolman.

Riley was District Forester. He tried to let me down easy and still stay right with the bunch. My ideas were interesting but "rather intensive," he said.

But Morrell, (then of Operations), later on, showed some interest. He allowed that maybe I could hire an extra Guard, presumably for sheep work, and maybe let him try the lookout thing. Thought it well worth trying. But how could he get word out if he saw a fire?

Well, I explained, I had somewhat "overestimated" the wire needed for the Keystone-Foxpark line. Had connected up some old line, in fact, had managed to get me some seven miles of extra No. 12, in fact, had gotten that wire strung, in fact, from Centennial to near the Blackjack, within a couple of miles of the Peak... Now if he could just get me about 30 miles of No. 9 to run from Laramie to Centennial, why we'd have a line and a lookout. I'd gouged a right-of-way for the wires on the poles of the Laramie Hahn's Peak and Pacific (railroad). Had it in writing. Big Chance. Perfect shame to have that odd section of seven miles where we couldn't get any use of it.

Morrell was a little shocked, I think, but still interested. But 30 miles of wire was too much. Evidently he knew that Riley would never OK it. I went back to Laramie quite down in the mouth. Morrell "would see" and that was all I could get out of him.

Meanwhile Mullison had doped out the idea of putting up a big Sibley tent stove on the Peak with a high, well -guyed stack and a damper on it. Fill stove full of dry wood and tar; see fire, slop on a quart of kerosene and touch it off. Big black smoke flag saying "fire in this country." Damper working to cut the smoke into blobs. Three blobs, "and she's District three. Get in gents." Lacking the phone wire we were going to try it. Also a set of big flags on as high a pole as we could set up.

But early next spring (1909), about March, with our corespondence came notice from freight house that we had 60 coils of barb wire. "Mistake," I thought "Ought to have gone to Routt for their big drift fence."

"Mistake?" said freight agent. "They billed barb wire and shipped phone wire. Just look. What'll I do with it?"

You know, I still thought it was a mistake and apt to be discovered directly. So I phoned Foxpark for all the boys but one to come and bring their climbers and guns. Borrowed a hand car from the LHP&P and loaded that wire on a flat (which we never paid for, I think) and Bill Will sat on that flat counting poles and every 30 he'd push a coil of wire.

Then we went out on that handcar and strung wire, borrowing the brackets from the Bell Company until next July when we'd have money to pay them back - maybe.

That was quite a job. Thirty miles of it with the March wind blowing so fast, that many times we couldn't stay on the right side of the pole. Bill claimed that

one gust blew against the pole so hard that when his spikes slipped he couldn't slide down for awhile....

The guns? Why McCabe was new Solicitor for the Department (under Taft) and the Ballinger outfit was in power and doing things to the Pinchot machinery. McCabe had ruled that no salary money could be spent on improvement work without being charged to Improvement Accounts. He knew, of course, that would cripple us; wanted it to, no doubt. We had to work the boys on Improvements whenever we could. So they had some six-shooters in the hand-car and we charged up our time to destroying predatory animals, begosh. "Say," we'd remark, as we got ready to stretch a new span, ""if I see one of them coyotes areound here, I'll certainly blow his head off, I will." Then we'd tension her up and tie and have another quarter mile toward a real lookout.

The boys recommended a man named Miller for the first lookout. End of the phone was on a dead spruce near Blackjack. Wall-set phone with a piece of oilcloth over it. Mean piece of country between the phone and the top, of course.

Having experience with excited and mixed fire reports, I had made a form and drilled Miller in its use. One PM in May, I think some weeks before fire season was expected anyway, the phone rang. Couldn't make out the trouble at first. "Dese as Millar," I got finally. He was panting so he could hardly talk. "Dese as Snovy Range Lookout. Aye got fire re-port nummer vun. Do you got it? She as sout fivteen an' von half Vest. Do you got it? She as across de continental de-wide - an' two de-wides more. Do you got it?"

Sixty-five miles as he guessed it. Way down in Colorado. No mistake he insisted. I tried to protract it off on the maps but we had only a four inch celluloid protractor and the state maps of Colorado and Wyoming were not on the same scale and I couldn't check Miller very well. It seems too blamed far. I hesitated to report the thing and so give the fact that I had a lookout working (unofficially) and, if it should be a false alarm or anything, get myself joshed or very officially bawled out. So I told Miller to stay on top till dark and see if the smoke showed up fire reflections and I'd wait up for him in the office. How he came down the French Creek face with a lantern I never found out, but he did, and confirmed the PM report. The fire was spreading fast he said. So I wired in to effect "Snowy Range Lookout reports fire South 15 - one half west, across three big Divides, he makes it headwaters of North Fork Elk. I make it in Routt. You notify Supervisor Routt." Then I waited for what might happen. Afterward I heard that the District Office couldn't understand my message. Snowy Range Lookout? What was that? How could Lovejoy report a fire way down on the Routt. Well, phone the Routt and see. Fire here? Hell no, said Routt. And when there was, they would report it before anybody up in Wyoming did, too.

So Denver wired me, asking for confirmation or explanation of my wire. Confirmation and report from Miller that the thing was getting worse all the time. Phone Routt again. Why yes, somebody had ridden down a relay of horses and the Super had gone. They lost something like half a township of timber, as I remember it.

And next Super meeting, the Super of Routt had the grace to stand up and take it all back ... and there was quite a chorus demanding money for lookout stations.

I never did find out how Morrell worked it with the wire. Guess he just juggled things at the warehouse and a voucher or so. Never well to inquire too

closely into such things... And they didn't get the wire to the top until after 1910. Miller did manage to scrape together enough material to build a cabin at the base of the peak (quoted from Bruce, 1959).

Grasslands and Shrublands

Grazing pressures were considered heavy enough to interfere with tree regeneration in the Sierra Madre (Blackhall 1909) and north of Medicine Bow Peak (Mullison 1909). In the Sierra Madre mountains, cattle grazing, rather than sheep, was recommended to keep aspen from sprouting so that lodgepole pine could replace aspen (MBNF 1925).

Grazing in the Medicine Bow and Sierra Madre Mountains was widespread and indiscriminant prior to the establishment of the National Forest in 1902. The Sierra Madre Mountains were so overgrazed in 1916 that Forest Supervisor Blackhall reported:

> The grazing industry of this section is nearly extinct, brought on by overstocking, in fact with the exception of that portion which is protected by the long period that the snow lies on the ground, the short summer season and the early advent of winter, it may be said that the country is destitute of all forage necessary to support animal life... (Bruce 1959).

Medicine Bow National Forest Administrative records clearly show that there were serious problems with range condition on the western slope of the Sierra Madre Mountains:

> ...the western slope ...has denuded areas made so by forest fires; old slashings and overgrazing before the establishment of the Sierra Madre Forest, now the Hayden. While the snowfall [on the western slope)] is equally as great [as on the eastern slope] with little protection from the warm winds and sun; flood waters are frequent in the spring there, causing erosion on every hand (Medicine Bow National Forest 1909), [ ] added for clarity).

> In past years it has been the policy of every sheepman to rush to the mountains as early in the spring as possible, keeping their flocks up to the snowline, and consequently not allowing any grass to even start to grow, and with this practice carried on for years it is little wonder the condition of the range became almost a barren waste (Medicine Bow National Forest 1909)

Gradually livestock numbers on the Forest were reduced (Table 4.4). At the same time, the establishment of grazing districts and allotments put limitations on livestock numbers and the timing and intensity of grazing.

Wildlife

State game regulations, begun about the same time as organization of National Forests, coupled with establishment of wildlife refuges, winter game ranges, and penalties against poaching, enabled a recovery of big game populations after elk and deer were reintroduced during the first two decades of the 1900s. Winter range, which was mostly on private or state land, was a serious limiting factor in reestablishing big game populations.

> The natural big-game winter range, between Brush Creek on the north and as far south as the Colorado-Wyoming State line is terribly overgrazed by domestic stock. In fact, I doubt if there is any similar large area, adjacent to a national forest in such overgrazed condition. Deer wintering on these ranges are forced to eat the bark from trees and shrubs in order to live through the winter... Stockmen do not favor range protection for game any more than he does for his stock; stockmen adjacent to this district seem to be more in favor of large numbers of poor cattle than fewer numbers of fatter cattle (Riggs, 1936).

Public interest in conservation was high before the Depression, based on the establishment of game refuges like Sheep Mountain and activities of conservation organizations, sportsmen's groups such as the Isaac Walton League, and support from local businessmen. While big game populations increased during this era, predators continued to be poisoned and shot. Poisoning of wolves, coyotes, and pocket gophers began around the turn of the century by ranchers and continued, under public sponsorship, for many decades. Sheep ranching was more prevalent in the early decades of the century and mountain lions were eradication targets because of predation on livestock, and newly introduced populations of deer, elk, and bighorn sheep.

Bears were also hunted, especially because of predation on sheep. Populations of smaller predatory cats, such as bobcat and lynx, apparently declined sharply after the drought years of the 1930s.

Wolverine, otter, and ptarmigan are mentioned in Forest Service Reports of the 1920s, but have suffered populations declinesor extirpation since then. Current data on populations of these animals is not available. Status of populations with Threatened, Endangered, Candidate, or Sensitive Species are discussed in the Chapter 8.

Table 4.4 Overview of Historical Grazing Outputs

Sheep		
1903	200,000 (3) (Cheyenne NF)[1]	
1904	160,000 head of sheep removed from Medbow Mtns. to Sierra Madre Mts.	
1907	330,000 - Hayden NF	
1909	240,000 - Hayden NF	
1915	183,000 sheep and goats (9) (MBNF)	
1921	56,660 (23)	
1924	50,000	[Add Pole Mountain Division in 1925]
1935	56,600**	[Add Laramie Peak Divison in 1935]
1940	56,400**	
1945	47,000**	
1950	35,400**	
1954	91,568 (40)	
1994	46,619 (46)	
Cattle		
1921	11,456	
1924	12,000	[Add Pole Mountain Division in 1925]
1935	12,740**	[Add Laramie Peak Division in 1935]
1940	12,340**	
1945	12,260**	
1950	10,240**	
1954	26,586 (40)	
1994	35,223 (46)	

( ) refers to Literature references for Tables. * Boundaries varied until about 1935. [1] The Cheyenne NF in 1903 included both the Sherman Mountains and the Medicine Bow Mountains; the Hayden NF included the Sierra Madre Mountains and 84,000 acres of the Park Range in Colorado; Pole Mountain was used for military maneuvers until 1925 when it was added to the MBNF; the Laramie Peak Division was added in 1935. ** courtesy of Clark McClung, Laramie Ranger District Range Staff Officer. Counting methods may vary between "head of livestock" (through about 1950) and AUM (animal unit months) which is how livestock outputs are currently counted.

The watershed value of the Medicine Bow National Forest, at the headwaters of many tributaries of the Platte and Little Snake Rivers, was recognized early in the 20th century:

> Sooner or later the flood waters of the North Platte will be stored and utilized for irrigation through the construction of many supply reservoirs. When this is done, the forest will have inestimable value to prevent sedimentation in the storage basins (Mullison 1909).

> With the exclusion of fires, it is probable that no cutting which does not remove over 2/3 of the stand, will have any serious effect on the water flow. Because of this, water conservation, which probably in the long run will prove the most important result of maintaining a forest, may be to some extent neglected for the preset, or perhaps until some method of clean-cutting (clearcut) is practiced (Mullison 1909).

AQUATIC AND RIPARIAN ECOSYSTEMS

Beaver Management

Trapping and tie driving removed beaver throughout the 19th century. In the 1920s, beaver transplants were conducted to achieve a better distribution of beavers and to improve watershed health. It was not until the 1930s, when game laws were enacted, that beaver populations began to recover in many areas of the Forest (Grasse and Putman, 1955). It was also about this time that live trapping and relocation of animals to headwaters of streams began (Grasse and Putman 1955). Beavers were reintroduced to the Pole Mountain Unit in 1928. Within ten years beavers had extremely high populations on both Pole Mountain and in other areas of the Forest. A beaver management plan was developed in 1938, under the leadership of Deputy Game Warden William Lakenen, to maintain adequate populations of beavers in desired areas. Lakenen and another deputy were murdered by beaver poachers in the Sierra Madre in 1945 (Medicine Bow National Forest 1951). Since then there has not been an organized, forest-wide approach to beaver management. Only in the Sherman Mountains are beavers managed under a limited quota system.

Fish Introductions

Aquatic ecosystems have been altered substantially because of introductions of non-native fish beginning in stream systems during the 1880s. Stocking of mountain lakes in alpine and subalpine areas began about 1910. Millions of fry

were planted, structures for holding and rearing fish were installed, and fertilization of high mountain lakes to improve production was tried. Fish stocking gathered momentum in the 1920s and 1930s and continues into the present. The effects of these introductions include competition and hybridization with native trout species and unknown effects on macroinvertebrates.

From 1900 to 1929, seven additional hatcheries were constructed around the State (Wiley 1993). Telephone, Brooklyn and Towner Lakes in the Snowy Range were stocked in 1905 (Will, 1932). Lenihan (1914) surveyed the waters of the Medicine Bow, Big Horn, and Wind River Ranges. He found numerous fishless lakes, including lakes in the Snowy Range on the Medicine Bow National Forest. Lenihan (1919) reported that 80 percent of Wyoming's lakes and streams were fishless in 1884 and observed that virtually all waters were stocked by 1918.

Lenihan (1919), and Bayne (1922) reported overfishing in streams and lakes on and off the Forest. They also emphasized the need for hatcheries to replenish depleted wild trout stocks and to stock barren lakes. From 1911 through 1931, over two million fish were stocked in 54 fishless lakes in the Snowy Range (Coughlin 1932).

During the 1930s the CCC built holding ponds and other structures which modified aquatic and riparian systems throughout the Medicine Bow National Forest.

Through the 1930s and 1940s, widespread stocking of various trout species continued in both the North and South Platte drainages. The earliest recorded extensive planting of exotic fish in the Little Snake River drainage of Wyoming occurred in the early 1930s and continued until around 1950. Simon (1940) identified the planting of exotic fish as one of the primary causes of extirpation of native trout. He developed a systematic, statewide fisheries management plan for Wyoming during 1939-1940 (Simon 1940). Under his plan, fishless waters were inventoried prior to planting, with priority given to native stocks.

1950 - 1995

Previous uses of resources continued, with new technologies and at larger scales, after World War II. New uses of terrestrial, riparian and aquatic resources also developed. Road infrastructure, especially in the Medicine Bow and Sierra Madre Mountains, increased along with clearcutting and partial timber harvest. Larger and more powerful harvesting equipment enabled harvest of more acres. A market for sawtimber encouraged harvesting of large, old growth forests at high elevations. Recreation uses became more important. Large scale water diversions to supply cities began during this time period.

TERRESTRIAL ECOSYSTEMS

Forests

Beginning in the late 1940s, "clean cutting" (clearcutting) was advocated as an appropriate way to manage timber resources and improve water yields. Clearcutting in alternate strips was instituted in 1945. By then there was demand for sawlogs as well as mine props and ties and, by the end of World War II, both lodgepole pine and Engelmann spruce were being used for lumber (Avery 1959). Since 1945, various configurations of clearcutting have been the dominant form of silvicultural treatment for both lodgepole pine and spruce-fir stands.

High elevation forests were cut for the first time. At lower elevations, lodgepole pine prolifically recolonizes cut areas. At higher elevations, tree regeneration is often slower and sparser. Mesic to hydric areas often convert to grasslands, forblands, and sedge meadows. Effects of 30-60 percent partial cutting on biological diversity, forest floor composition, forest structure, and tree regeneration at high elevations has not been monitored.

To support increased harvest levels, an extensive infrasructure of roads was constructed. The majority of the present transportation system in place now (1995) in the Medicine Bow and Sierra Madre Mountains was completed by the early 1980s. Large areas of the Medicine Bow Mountains have been extensively logged since 1950. Timber harvest is less widespread in the Sierra Madre Mountains. Fewer roads have been built in the Laramie Mountains and timber harvest has been mainly in ponderosa pine near Albany Peak, Black Mountain, Friend Park, and Laramie Peak in the past 15 years. Increasing timber harvest on intermingled private and state land has unknown effects on NFS lands.

Numerous studies have documented the effects of timber harvest and roads on stream habitats (Chamberlin et al. 1991; Furniss et al. 1991; Eaglin 1991; Reid 1993). Specific studies on the Medicine Bow National Forest include Eaglin (1991) and Marston and Wick (1994).

Wildlife

Adqeuate winter range is still a limiting factor to big game herd size. Conservation regulations, wilderness area designations, and changing grazing allotment management have resulted in the improved range condition and wildlife populations. Large predators such as bears and cougars are hunted, but the status of their populations is not well-known.

Effects of timber harvest on wildlife populations have varied from improving habitat for large game animals to possible population fragmentation and

extirpation or genetic isolation for others. There is insufficient information to evaluate impacts of timber harvest on most species because there have not been pre-harvest or post-harvest censuses over large enough areas or long enough times to determine trends.

Increasing interactions between recreationists and wildlife are expected because of the proximity of the MBNF to the Front Range and easy road access to most areas. Further analysis of this will be done as part of the Forest Plan revision.

Wildlife preservation and recreational use may be conflicting goals for wildland management for some species (Cole and Knight 1991). Effects of recreational activities on wildlife are poorly studied at this time but are receiving increased attention. Effects on wildlife populations include 1) immediate effects on individuals, 2) long-term effects on individuals, 3) long-term effects on populations, and 4) long-term effects on communities. Snowmobiles can crush small mammals in subnivean chambers, foraging areas may change and physiological stresses can be induced which reduce vigor and increase suseptibilty to disease, populations may be displaced to inferior habitats, changed behavior by a key species may alter ecosystem support characteristics for others (Knight and Cole 1991). Knight and Gutzwiller (1993) have recently reviewed the subject of wildlife and recreationists.

AQUATIC AND RIPARIAN ECOSYSTEMS

Tie-driven Streams

Return of tie-driven streams to previous stream channel configuration and characteristics will largely depend on the re-establishment of mature trees in the riparian zones. Uneven aged stands would provide a continual supply of large trees contributing large organic debris to the stream channel. Under natural successional processes, such recovery is expected to take well over 100 years (Young et al. 1994).

Beavers and Riparian Areas

The removal of beaver from aquatic systems had, and continues to have dramatic effects on riparian habitat (Parker et al. 1985). In Wyoming marked changes in riparian zones have occurred since the mid 1800s. Shute (1981) estimated that beaver removal caused severe erosion on 80 percent of the streams in southwestern Wyoming. Muddy Creek, in the Little Snake River drainage, has experienced major changes such as severe channel downcutting and lowering of water tables (Parker et al. 1985).

In the Laramie Mountains many meadows and streambanks have substantial riparian areas (some on private or state land) within NFS range allotments where willows are extirpated or stunted from browsing and mechanical damage and beaver populations are low and poorly distributed. The mixed land ownership pattern makes this a very complicated situation.

Beaver populations are well distributed and common in the Medicine Bow Mountains. Beavers are managed under a limited quota harvest system in the Sherman Mountains. There are some places in both the Sierra Madre Mountains at lower elevations, and in the Laramie Mountains where both riparian habitat and beaver populations could be monitored and condition of riparian systems improved.

The effects of beaver removal on stream channels and riparian areas have been documented on Pole Mountain (Call 1970) and in the Laramie Peak area (von Ahlefeldt, personal observation). The Laramie Mountains have a mixed land ownership pattern and most riparian areas are in private or state ownership. National Forest Lands with substantial riparian areas are in LaBonte Canyon, upper tributaries of the Deer Creek Mountains, and on Laramie Peak.

The widespread removal of beaver, especially in headwater streams, might affect riparian and aquatic ecosystems on the forest by the following mechanisms as modified from Olsen and Hubert (1994):

-Reducing wetland area
-Lowering water tables and reducing the water available for subirrigation
-Reducing forage and cover if dewatered areas are grazed heavily
-Increasing high flows and the potential for downstream flooding
-Reducing watershed stability
-Reducing late summer flows
-Reducing sediment and organic matter retention
-Decreasing invertebrate production
-Decreasing aquatic productivity

Riparian ecosystems on the Medicine Bow National Forest have improved since the turn of the century as a result of livestock management. The Land and Resource Management Plan of the Medicine Bow National Forest has a riparian standard to "maintain all riparian ecosystems in at least an upper mid seral successional stage." In 1993, 46 percent of the riparian areas within allotments met this standard. Thirty-seven percent were moving toward compliance and 17 percent were not meeting the standard (Medicine Bow National Forest 1993). Site-specific noncompliance areas occur in the Laramie Mountains and portions of the Sandstone and Battle Creek drainages on the Sierra Madre portion of the Forest (Erhard, 1989; Safranic, personal communication).

Water Projects and Sediment Spills

Water projects including snow-manipulation, cloud seeding, trans-mountain diversions, and construction of large reservoirs have altered both terrestrial and aquatic ecosystems in ways ranging from obliteration to minor modification.

In 1964, the city of Cheyenne completed Stage I of its Water Development Plan. Stage I consists of water diversions from two major drainages in south central and southeastern Wyoming. Water is diverted from the headwaters of the North Fork Little Snake drainage into a pipeline. The diverted water travels through the Continental Divide via tunnel and into Hog Park Reservoir. Water diverted to the North Platte River by this system replaces water from the Douglas Creek drainage in the Snowy Range which is diverted to the City of Cheyenne for municipal use. Instream flows have been established on all the Stage I and II streams on the forest.

Construction of Stage II of the Cheyenne Water Project was initiated in 1982 and included a gravity flow collection system similar to that used in Stage I. The second aspect of Stage II involves a 25-mile long collection system in the headwaters of the North Fork Little Snake River. Diversion structures have been constructed on every major tributary in the headwaters of the drainage. Water collected by the system passed through the Continental Divide and flows down Hog Park Creek into Hog Park Reservoir. The majority of the additional water is collected from Douglas Creek and its tributaries.

As a result of construction of the Stage II pipeline, several water quality violations occurred in the North Fork drainage between 1983 and 1993 (Hipple, 1986; Schmal, 1986; Wilcox, 1989). Sediment input into channels exceeded inputs attributable to the pre-pipeline construction system. The sediment inputs appear to be exceeding stream transport capabilities. The largest of these events occurred in 1988. Approximately 2000 cubic yards of sediment were discharged down Henry Creek into Green Timber Creek, impacting approximately three quarters of a mile of stream (Photos H15-H18).

In the spring of 1992 and again in 1993, other sediment spills occurred at the point where the Stage I pipeline crosses Green Timber Creek. Approximately 500 yards of Colorado River cutthroat trout (CRCT) habitat were directly affected by these sediment spills. Monitoring conducted by Wyoming Game and Fish and Forest Service biologists in 1988, 1989, and 1992 demonstrated that trout standing stocks have been decreased by the sediment spills. Studies conducted by the Forest Hydrologist on the Medicine Bow National Forest indicate a projected recovery time of at least 20 years before sediment is transported from Green Timber Creek into the North Fork Little Snake River (Wilcox 1989).

Deadman Creek, the West Branch, Rabbit Creek, Standard Creek, and Third Creek all experienced declines in population numbers of trout from 1986 at stations located upstream from the diversion structures (Oberholtzer 1990). Collection structures on both Stage I and II pipelines appear to block movement of fish into the upper areas of affected streams or are allowing fish to leave the system through the pipeline. Because the upper Snake River drainage contains populations of Colorado River cutthroat trout, restriction of upstream or downstream movement of Colorado River cutthroat trout and other trout species has important implications for CRCT as a species.

Jespersen (1981) indicated that headwater areas in the North Fork Little Snake River drainage provided some of the best spawning habitat and highest fry survival rates. He further documented that young fish surviving in the upper reaches move downstream as they increase in size and require habitat with greater depth, thus providing recruitment to downstream areas.

Fish Introductions

Streams and high elevation lakes are annually stocked with non-native species of trout. Colorado River cutthroat trout, which now occupy less than 1 percent of their historic range from Wyoming to Arizona, are found in the upper Snake River Drainage in the Sierra Madre Mountains. Genetically pure populations are protected by both natural and man-made barriers. Most populations are within the Huston Park Wilderness. The species is on the Region 2 Sensitive species list and was a USFWS Category 2 species. See Chapters 7 and 8 and Young (1995) for a full discussion of Colorado River cutthroat trout and the status of native and non-native fish.

Timber Harvest

Timber havest can have the following effects on aquatic ecosystems:

1. Some methods of timber harvest, particularly clear cutting, can alter the timing and duration of spring high flows which can increase bed scour or accelerate bank erosion.

2. Streambank erosion from the removal of trees in riparian areas increases sediment supply and reduces the amount and size of trees available for recruitment as large woody debris into the stream channel.

3. Changes in energy relationships occur which affect aquatic processes. These changes include water temperature, snowmelt, and freezing.

Note: similar effects can occur from natural disturbances such as fire, which remove trees.

Roads

Road construction has several effects on aquatic and riparain areas:

1. Where roads are constructed on steep terrain or in areas prone to mass wasting, soil mass movement can increase or be the primary cause of increased sediment loads in streams. This can cause siltation of gravel beds used for fish spawning.

2. Surface erosion from road surfaces, drainage ditches, and cut and fill surfaces can affect streams below crossings.

3. Channel morphology can be altered through installation of culverts and construction of roads adjcent to streams.

4. Road construction and inadequate road maintenance can cause substantial increases in channel dimensions and drainage density because of increased flow.

5. Improperly placed or poorly maintained culverts can restrict migration pathways of fish.

Recreation

Riparian areas are particularly attractive for recreational use. Seven types of impacts of recreation on biodiversity in wilderness areas, applicable largely to riparian ecosystems, were identified by Cole and Knight (1990): 1) construction of trails, 2) trampling of vegetation on soils on trails and at campsistes, 3) collection and burning of wood in campfires, 4) water pollution associated with camping activities, 5) unintentional harassment of animals, 6) hunting, fishing, and associated management programs, and 7) grazing by recreational packstock. These are all applicable to both wilderness and non-wilderness areas on the MBNF. Increasing use of off-road vehicles and snowmobiles cause additional effects. Systematic cata are lacking for most areas, so area-specific and/or species-specific effects are largely unknown.

LITERATURE CITED

Armstrong, P.L. 1935. History of the Medicine Bow National Forest Service. Unpublished manuscript. Wyoming State Archives and Historical Department, Cheyenne, WY.

Axelrod, D.I.; Raven, P.H. 1985. Origins of the Cordilleran flora. Journal of Biogeography 12: 21-47.

Avery, N. 1959. Statement of Ned Avery for Forest History - Observations gleaned from old timber sale folders and 22 years experience on the Medicine Bow. Medicine Bow Collection. American Heritage Center. Laramie, WY.

Baker, R.G. 1983. Holocene vegetational history of the Western United States. IN: H.C. Wright, Jr. Ed. Late-Quaternary environments of the United States. Vol. 2 The Holocene: 109-127 Minneapolis, MN.

Barkwell, M.C. 1883. Report of the Board of Fish Commissioners for the two years ending December 31, 1883. Wyoming Game and Fish Department. Cheyenne, WY.

Bayne, B. 1922. Biennial report of the state fish hatcheries for the State of Wyoming, 1911-1922. Wyoming Game and Fish Department, Cheyenne, WY.

Berglund, B.E. 1986. Handbook of Holocene paleocology and paleohydrology. John Wiley and Sons, New York.

Blackhall, J. 1909. Report for the Forest Atlas - Hayden National Forest. Medicine Bow Collection.

Blackhall, J. 1915. Information on Hayden National Forest. Unpublished Administrative Report. Medicine Bow Collection Americain Heritage Center University of Wyoming, Laramie, WY.

Bradley, R.G.; Jones, P.D. 1992. Climate since AD 1500. Chapman and Hall. London

Briffa, K.R.; Jones, P.D. 1992. Tree-ring density reconstructions of summer temperature patterns across Western North American since 1600. Journal of Climate 5(7): 35-754.

Bruce, R.K. 1959. History of the Medicine Bow National Forest, 1902-1910. Master's Thesis. University of Wyoming.

Call, M.W. 1970. Beaver pond ecology and beaver-trout relationships in southeastern Wyoming. PhD Dissertation. University of Wyoming, Laramie, WY.

Carahar, D.L.; Henshaw, J.; Hall, F.; Knapp, W.H.; McCammon, B.P.; Nesbitt, J.; Pedersen, R.J.; Regenovich, I.; Tietz, C. 1992. Restoring ecosystems in the Blue Mountains: A Report to the Regional Forester and the Forest Supervisors of the Blue Mountain Forests. USDA Forest Service Pacific Northwest Region. Portland, OR.

Chamberlin, T.W.; R.D. Harr; Everest, F.H. Timber harvesting, silviculture and watershed processes. IN: Influences of Forest and Rangeland Management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 181-205.

Cole, D.N.; Knight, R.L. 1990. Impacts of recreation on biodiversity in wilderness. IN: Proceedings Wilderness areas: their impact. pages 33-40. Utah State University, Logan, UT.

Cole, D.N.; Knight, R.L. 1991. Wildlife preservation and recreational use: conflicting goals of wildland management. Transactions 56th North American Wildlife and Natural Resources Conference. pages 233-237.

Coughlin, L.E. 1932. Letter to Wm. F. Will, Wind River Nursery. Stabler, WA. Medicine Bow Collection. American heritage Center.

Covich, A.; Rudman, B.; Smith, S.; Kennedy, P.; Cooper, D.; Fausch, K.; Wilson, K. 1994. Literature review on the range of natural variation in the Colorado Front Range and associated grasslands. Unpublished Report prepared for the Arapaho-Roosevelt National Forest, Fort Collins, CO.

Crabtree, D.R. 1987. Angiosperms of the northern Rocky Mountains: Albian to Campanian (Cretaceous) megafossil floras. Annals of the Missouri Botanical Gardens 74: 707-747.

Dary, D. 1986. Entrepreneurs of the Old West. University of Nebraska Press, Lincoln, NE.

Davis, M.B. 1989. Lags in vegetation response to greenhouse warming. Climatic Change 15: 75-82.

Department of the Interior. 1874. Report of the Secretary of the Interior to the two Houses of Congress . Volume 1: 255-259. Report of the Surveyor-General of Wyoming Territory. U.S. Government Printing Office Washington, D.C.

Dix, R.L. 1964. A history of biotic and climatic changes within the North American grasssland. IN: Grazing in terrestrial and marine environments. Blackwell Scientific Publications Aldred and Son Ltd. Dorking, England.

Duncan, M. 1990. The Medicine Bow mining camps. Jelm Mountain Publications. Laramie, WY.

Duncan, M. 1992. Place Names of the Medicine Bow National Forest. Jelm Mountain Publications. Laramie, WY.

Dunlap, F. 1906. Report on dead and mature timber in the Cheyenne Forest Reserve, Colorado and Wyoming. USDA Forest Service Unpublished Report.

Duthie, G.A. 1916. The Medicine Bow National Forest, 1913-1916. Unpublished administrative report. Box 4 Medicine Bow Collection, American Heritage Center. Laramie, WY.

Eaglin, G.S. Influence of logging and road construction on trout streams, Medicine Bow National Forest. Master's Thesis. University of Wyoming, Laramie, WY.

Earle, C.J. 1993. Forest dynamics in a forest-tundra ecotone, Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Washington, Pullman, WA.

Elias, S.A. 1985. Paleoenvironmental interpretations of Holocene insect fossil assemblages from four high-altitude sites in the Front Range, Colorado, U.S.A. Arctic and Alpine Research 17: 31-48.

Elliott-Fisk, D.L.; Adkins, B.S.; Spaulding, J.L. 1983. A re-evaluation of the postglacial climate of the Laramie Basin, Wyomng-Colorado. Great Basin Naturalist 43(3): 377-384.

Ensign, E.T. 1888. Report on the Forest conditions of the Rocky Mountains - especially the State of Colorado, the Territories of Idaho, Montana, Wyoming and New Mexico. Pages 111-112 (Albany and Carbon Counties, WY) USDA Forestry Division Bulletin 2 Washington, D.C.

Erhard, D. 1989. Douglas District riparian project. Douglas Ranger District, Douglas WY.

Fall, P.L. 1985. Holocene dynamics of the subalpine forest in Central Colorado. IN: Late-Quaternary vegetation and climates of the American Southwest. Editors B.F. Jacobs, P.L. Fall, and O.K. Davis. pp. 31046. American Association of Stratigraphic Palynolgists Foundation. Contributions Series 16.

Fawcett, W.B., Jr.; Francis J. 1981. An archaeological survey of portions of the Medicine Bow National Forest. Albany and Carbon Counties, Wyoming Contract No. 53-82C9-0-179 Wyoming Office of the State Archeologist, University of Wyoming and U.S. Forest Service. Unpublished Report Medicine Bow National Forest Laramie, WY.

Fernow, B.E. 1888. Annual report of the Division of Forestry Wyoming. pages 137-138. U.S. Government Printing Office, Washington, D.C.

Flora of North America Editorial Committee. 1993. Flora of North America. Vol. 1 Oxford University Press. New York.

Fremont, J.C., Brevet. Capt. 1845. The exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843 and'44. pages 123-124. Printed by Order of The House of Representatives. Blair and Rives, Washington, D.C.

Furniss, M.J.; Roelofs, T.D.; Yee, C.S. Road construction and maintenance. IN: Influence of Forest and Rangeland Management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19: 297-323.

Grasse, J.E.; Putnam, E.F. 1955. Beaver management and ecology in Wyoming. Federal Aid in Wildlife Restoration Project, Bulletin No. 6. Wyoming Game and Fish Commission, Cheyenne, WY.

Grasso, D.N.; Thybony, S.; Rosenberg, R.; Rosenberg, E. 1981. Cultural resource overview - Medicine Bow National Forest including The Thunder Basin National Grassland Volume I: Medicine Bow National Forest. High Plains Consultants Inc. Contract No 53-82X9-1-122. Unpublished Report Medicine Bow National Forest, Laramie, WY.

Grayson, D.K. 1993. The desert's past: a natural prehistory of the Great Basin. Smithsonian Institution Press. Washington, D.C.

Gumtow, R.; DiRienzo, B.; Frederick, K. 1994. 1994 Wyoming Water Quality Assessment. Water Quality Division of the Wyoming Department of Environmental Quality (DEQ). Cheyenne, WY.

Habeck, J.R. 1987. PresentdDay vegetation in the northern Rocky Mountains. Annals of the Missouri Botanic Gardens 74: 804-840.

Hayden, F.V. 1871. 4th Annual report of the United States Geological Survey for Wyoming and portions of contiguous territories. US Department of the Interior, United States Geological Survey: 11-25; 76-81; 112-130. Washington, D.C.

Hipple, B. 1986. Summary of washouts at Deadman Creek, First Creek, Second Creek, and Rose Creek on Stage II Little Snake River diversion pipeline. Specialist Report, Medicine Bow National Forest, Laramie, Wyoming.

Houghton, M.D. 1904. View of southern Wyoming - Copper Belt Edition. Grand Encampment, WY: Herald Publishing Company.

House of Representatives. 1890. The Executive Documents of the House of Representatives 1889-1890. Government Printing Office Washington, D.C.

Hunter, M.L.; Jacobson, G.L. Jr.; Webb, T. III. 1988. Paleoecology and the coarse-filter approach to maintaining biological diversity. Conservation Biology 2(4): 375-385.

Jackson, D. 1970. The expeditions of John Charles Fremont. Maps 2 and 4. Map Portfolio University of Illinois Press, Urbana, Ill.

Jesperson, D.M. 1981. A study of the effects of water diverstion on the Colorado River cutthroat trout (*Salmo clarkii pleuriticus*) in the drainage of the North Fork of the Little Snake River in Wyoming. Master's Thesis. University of Wyoming.

Kim, H.B. 1993. Soil morphology and genesis along an elevational transect, Snowy Range and Laramie Basin, WY. Master's Thesis. University of Wyoming, Laramie, WY.

Knight, R.L.; Cole, D.N. 1991. Effects of recreational activity on wildlife in wildlands. Transactions 56th North American Wildlife and Natural Resources Conference. pages 238-247.

Knight, R.L.; Gutzwiller, K.J. 1993. Wildlife and recreationists. Island Press Covelo, CA.

Larson, T.A. 1978. History of Wyoming. 2nd ed. University of Nebraska Press. Lincoln, NE.

Lenihan, J.J. 1914. First annual report of the State Fish Commissioner. June, 1913 to September, 1914. Wyoming State Archives. Cheyenne, WY.

Lenihan, J.J. 1919. Sixth annual report to the State Fish Commissioner, 1919, Wyoming State Archives, Cheyenne, WY.

Lovejoy, P.S. 1909. Report for the Forest Atlas. Administrative Report for the Medicine Bow National Forest Medicine Bow Collection. American Heritage Center. University of Wyoming.

McClammer, J.U.; Crabtree, D.R. 1989. Early Cretaceous to Paleocene paleobotanical collections in the western interior of North America. Review of Paleobotany and Palynology 57: 221-232.

McMahon, T.J. 1990. Pleistocene soils on the Medicine Bow Mountains, WY. PhD Dissertation. University of Wyoming.

McMahon, T.J.; Munn, L.C. 1991a. Early and Middle Pleistocene paleosols in the Medicine Bow Mountains, Wyoming. Soil Science: 152(6): 472-484.

McMahon, T.J.; Munn, L.C. 1991b. Soil developed in Late Pleistocene till, Medicine Bow Mountains, Wyoming. Soil Science 152(5): 377-388.

Marston, R.A.; Wick, D.A. Natural variablity and forestry impacts in mountain streams of southeastern Wyoming. IN: Effects of human-induced changes on hydrological systems. Proceedings of the Annual summer Symposium of the American Water Resources Association. Jackson Hole, WY.

Martin, W. A. 1951. Light-In-Darkness - A tale of the early LaBonte. Mountain States Lithographing. Casper, Wyoming.

Medicine Bow National Forest. 1905. Report on Medicine Bow Forest Reserve - Wyoming. USDA Forest Service Medicine Bow Collection.

Medicine Bow National Forest. 1925. Preliminary plan - Hayden National Forest. Medicine Bow Collection.

Medicine Bow National Forest. 1951. Historical files. Medicine Bow Collection. American Heritage Center. University of Wyoming, Laramie, WY

Miller, C.N. 1987. Land plants of the northern Rocky Mountains before the appearance of flowering plants. Annals of the Missouri Botanic Gardens 74:692-706.

Miller, L. 1890. Report of Louis Miller, State Fish Commissioner of Wyoming for the year ending September 30, 1890. Wyoming Game and Fish Department, Cheyenne, WY.

Mitchell, V.L. 1976. The regionalization of climate in the western United States. Journal of Applied Meterology 15: 920-927.

Mock, C.J. 1991. Historical evidence of a cold, dry summer during 1849 in the northeastern Great Basin and adjacent Rocky Mountains. Climatic Change 18:37-66.

Morgan, P.; Aplet, G.H.; Haufler, J.B.; Humphries, H.C.; Moore, M.M.; Wilson, W.D. 1994. Historical range of variability: A useful tool for evaluating ecosystem change. IN: Assessing Forest Ecosystem Health in the Inland West. pages 87-111. The Haworth Press.

Mullison, J.H. 1909. Report for the Forest Atlas. Administrative Report for the Medicine Bow National Forest. Medicine Bow Collection. American Heritage Center. University of Wyoming.

Mullison, J.H.; Lovejoy, P.S. 1909. History of the Cheyenne National Forest. Administrative Report for the Medicine Bow National Forest. Medicine Bow Collection. American Heritage Center. University of Wyoming, Laramie, WY.

Naiman, R.J.; Melillo, J.M.; Hobbie, J.E. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67: 1254-1269.

Neal, C. 1986. In pursuit of Parkman. The Journal of the West. October, 1986.

Neelan, C.; DeBoi, G.; Mock, P.; Wolff, K.; Claybaugh, T. 1994. Literature review for the Routt National Forest to assist with the determination of the range of natural variablity. 3rd Draft 12/94 Routt National Forest. Steamboat Springs, CO.

Neilson, R.P.; Wullstein, L.H. 1983. Biogeography of two southwest American oaks in relation to atmospheric dynamics. Journal of Biogeography 10(4):275-297.

Oberholzer, M. 1990. Current status of Colorado River cutthroat trout in the Little Snake River Enclave. Wyoming Game and Fish Department Report 5090-28-8501. Cheyenne, WY

Olsen, R.; Hubert, W.A. 1994. Beaver: Water resources and riparian managers. University of Wyoming, Laramie, WY.

Parker, M.; Wood, F.J.; Smith, B.H.; Elder, R.G. 1985. Erosional downcutting in lower order riparian ecosystems: Have historical changes been caused from removal of beaver? Pages 35-38 IN: Riparian Ecosystems and their Management: Reconciling Conflicting Uses. North American Riparian Conference USDA Forest Service General Technical Report Tuscon, AZ.

Parkman, F. 1950. Chapters 13, 17, 18, 19 IN: The Oregon trail. New York. Mentor Books.

Pielou, E.C. 1991. After the ice age: the return of life to glaciated North America. Unversity of Chicago Press Chigaco, Ill.

Pinchot, G. 1899. Report of The Forester for 1899. USDA Government Printing Office Washington, D.C.

Pinkerton, J.T. 1981, Knights of the Broadax - the story of Wyoming Tie Hack. The Caxton Printers, Ltd. Caldwell, ID.

Reid, L.M. 1993. Research in cumulative watershed effects. USDA Forest Service PSW-GTR-141. Albany, CA.

Reider, R.G. 1983. A soil catena in the Medicine Bow Mountains, Wyoming, U.S.A. with reference to paleoenvironemntal influences. Arctic and Alpine Research 15(2): 181-192.

Riggs, R. 1936. Report on Fish and Game - Brush Creek District. Medicine Bow Collection.

Ritchie, J.C. 1986. Vegetation-climate equilibrium in relation to paleoecology. Vegetatio 67: 65-74.

Ritchie, J.C. 1987. Postglacial vegetation of Canada. Cambridge University Press. Cambridge, England.

Rosenberg, R.G. 1984. Handhewn Ties in the Medicine Bows. Annals of Wyoming 56(1): 39-55.

Ross, H.H. 1972. The origin of species diversity in ecological communities. Taxon 21(2/3): 253-259.

Safranic, K. 1994. Hayden Ranger District. Personal communication.

Schmal, R.N. 1986. Evaluation of water quality violations occurring in the North Fork of the Little Snake River, 1983-1985, associated with the Cheyenne State II Water Development Project. Unpublished Specialist Report. Medicine Bow National Forest, Laramie, WY.

Schnitger, G. 1898. Biennial Report of the State Fish Commissioners of Wyoning for the years 1897 and 1989. Wyoming Game and Fish Department. Cheyenne, WY.

Scuderi, L.A. 1993. A 2000-year tree ring record of annual temperatures in the Sierra Nevada Mountains. Science 259: 1433-1436.

Shute, D.A. 1981. Decline of riparian communities in a portion of southwestern Wyoming. Unpublished report, Wyoming Natural Heritage Program - The Nature Conservancy. Cheyenne, WY.

Simon, J.R. 1940. Report of the Fish Division. Pages 31-41 IN: Robert Grieve, Biennial Report of the Wyoming Game and Fish Commission, 1939-1940. Wyoming Game and Fish Department.

Simon, J.R. 1951. Wyoming Fishes. Bulletin No. 4. Wyoming Game and Fish department, Cheyenne, WY.

Stockton, C.W.; Meko, D.M. 1983. Drought recurrence in the Great Plains as reconstructed from long-term tree ring records. Journal of Climate and Applied Meterology. 22: 17-19.

Swanson, F.J.; Jones, J.A.; Wallin, D.O.; Cissel, J.H. 1993. Natural variablity - implications for ecosystem management. IN: pp. 89-103. M.E. Jensen and P.S. Bourgeron (eds). Ecosystem Management: Principles and Applications. Vol. II Eastside Forest ecosystem health assessment. USDA Forest Service, Pacific Northwest Research Station, Forestry Science Laboratory, Wenatchee, WA.

Thybony, S.; Rosenberg, R.G.; Rosenberg, E.M. 1986. The Medicine Bows - Wyoming's mountain country. Caldwell, Idaho, Caxton Press.

Torrey, J. 1845. Catalogue of plants collected by Lieutenant Fremont in his Expedition to the Rocky Mountains. IN: Fremont, J.C. The Exploring Expedition to the Rocky Mountains. 1988. Smithsonian Institution Press. Washington, London.

Townsend, J.K. 1978. Across the Rockies to the Columbia. University of Nebraska Press, Lincoln, NE.

USDA Forest Service. 1991. Supplemental information report, Trail Creek Timber Sale Wisdom Ranger District, Beaverhead National Forest, Dillon, MT.

USDA Forest Service. 1994. Range of natural variability. III-5-III-8 and Appendix A. IN: Draft Environmental Impact Statement Black Hills National Forest, Custer SD.

USDI. 1897. Annual reports of the Department of Interior for the fiscal year ended June 30, 1897. Government Printing Office Washington, D.C.

Wade, M. 1947. The Journals of Francis Parkman. Harper Publishing Co.

Webb, T.W., III. 1987. The appearance and disappearance of major vegetational assemblages: Long-term vegetational dynamics in eastern North America. Vegetatio 69: 177-187.

Weidler, B. 1995. Edaphic characteristics of four Rocky Mountain soils, Medicine Bow Mountains, Wyoming. Master's Thesis (In progress). University of Wyoming, Laramie, WY.

Wells, P.V. 1970a. Vegetational history of the Great Plains: A post-glacial record of coniferous woodland in southeastern Wyoming. IN: Dort, W., Jr. and J.K. Jones (eds). Pleistocene and Recent Environments of the Great Plains. Department of Geography University of Kansas Special Publications No. 3 Lawrence, KA.

Wells, P.V. 1970b. Postglacial vegetational history of the Great Plains. Science 167: 1574-1582.

Wesche, T.A. 1987. Habitat restoration plan for Douglas Creek. Contract for Medicine Bow National Forest, Laramie, WY.

Whitlock, C. 1993. Postglacial vegetation and climate of Grand Teton and southern Yellowstone National Parks. Ecological Monographs 63(2):173-194.

Wilcox, M. 1989. Green Timber Creek timber sale. Specialist Report. Medicine Bow National Forest. Laramie, WY.

Wiley, R.W. 1993. Wyoming fish management. Wyoming Game and Fish Administrative Report. Cheyenne, WY.

Will, W.F. 1932. Letter to L.E. Coughlin, Acting Forest Supervisor, Medicine Bow National Forest. Laramie, WY. Medicine Bow Collection. American heritage Center

Wing, S.L. 1987. Eocene and Oligocene floras and vegetation of the Rocky Mountains. annals of the Missouri Botanic Gardens 74: 748-784.

Wolfe, J.A. 1987. An overview of the origins of the modern vegetation and flora of the Northern Rocky Mountains. Annals of the Missouri Botanic Gardens 74: 785-803.

Wood, R.D. 1988. Medicine Bow tie hack resources: material culture and social structure. Master's Thesis University of Wyoming, Laramie, WY.

Wood, D. 1995. Personal communication. Archaeologist, Laramie District, Medicine Bow National Forest.

Wright, H.E., Jr. 1976. The dynamic nature of Holocene Vegetation Quaternary Research 6: 581-596.

Young, M.K. 1995. Colorado River cutthroat trout. IN: Young, M.K. (ed.) Conservation assessment for inland cutthroat trout. USDA Forest Service General Technical Report RM-GTR-256. Fort Collins, CO.

Young, M.K.; Schmal, R.N.; Sobczak, C.M. 1989. Railroad tie drives and stream channel complexity; past impacts, current status and future prospects. SAF National Conference Wildlife and Fish Session. Spokane, WA.

Young, M.K.; Haire, D.; Bozek, MA. 1994. The effect and extent of railroad tie drives in streams of southeastern Wyoming. Western Journal of Applied Forestry 9(4): 125-130.

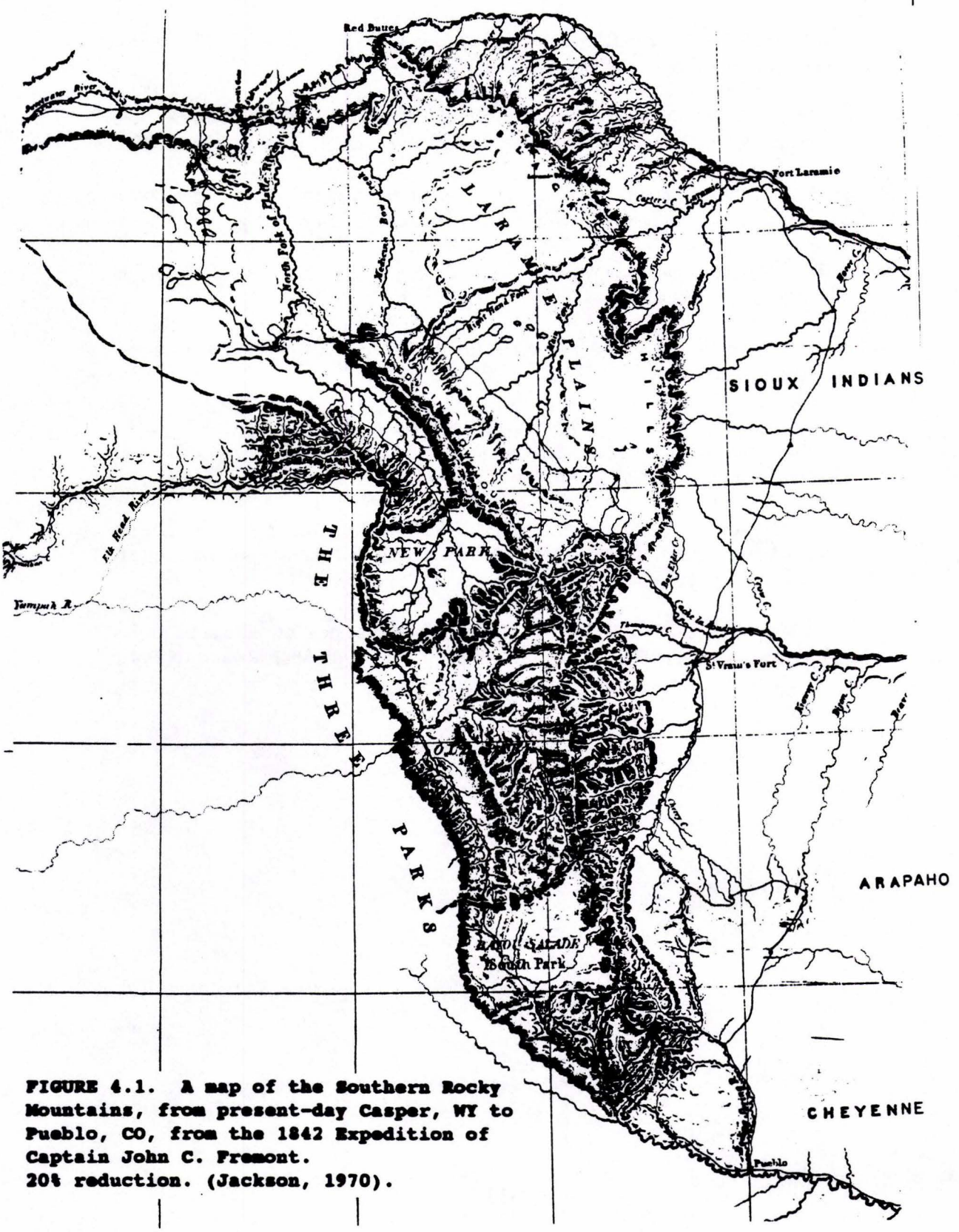


FIGURE 4.1. A map of the Southern Rocky Mountains, from present-day Casper, WY to Pueblo, CO, from the 1842 Expedition of Captain John C. Fremont. 20% reduction. (Jackson, 1970).

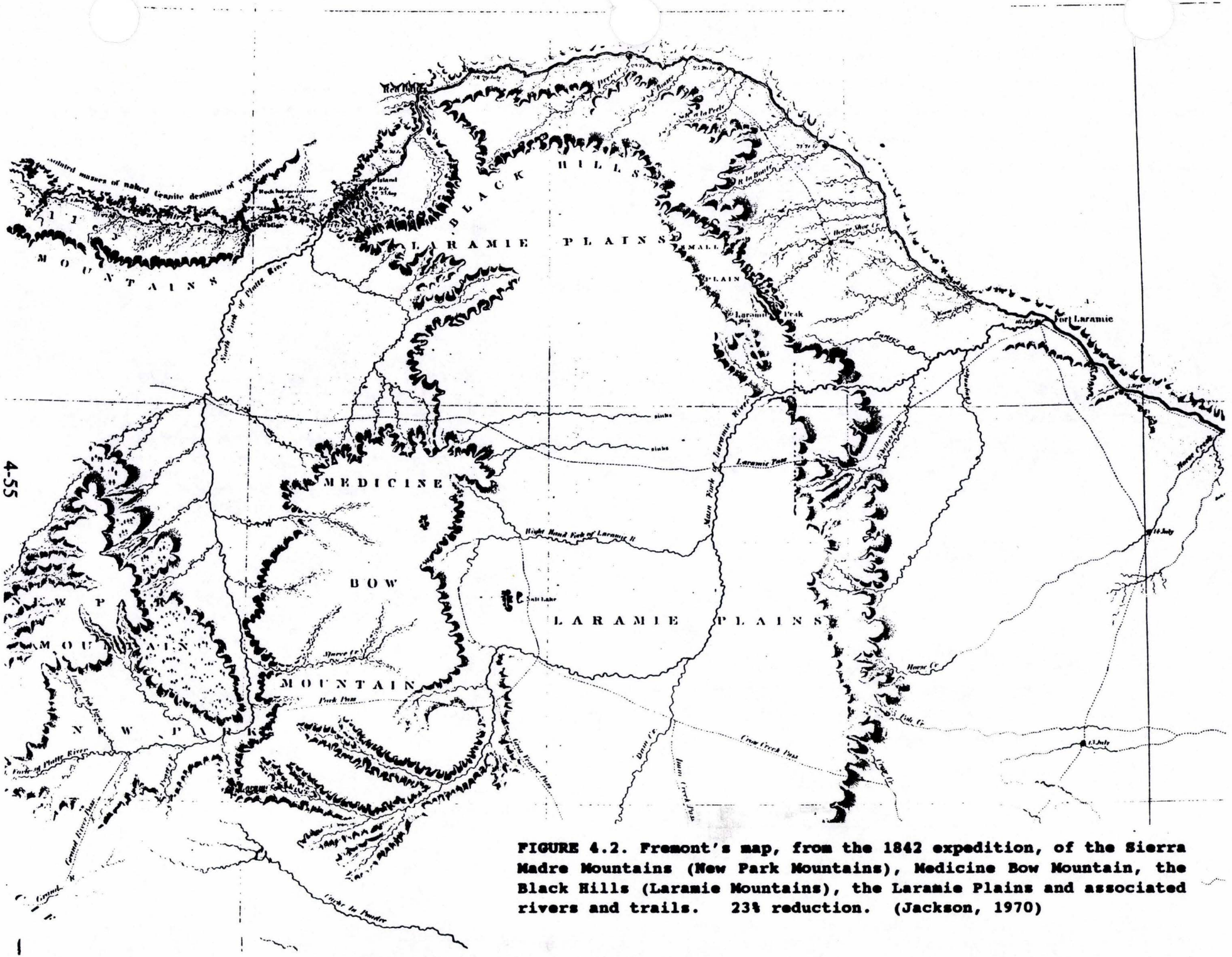


FIGURE 4.2. Fremont's map, from the 1842 expedition, of the Sierra Madre Mountains (New Park Mountains), Medicine Bow Mountain, the Black Hills (Laramie Mountains), the Laramie Plains and associated rivers and trails. 23% reduction. (Jackson, 1970)

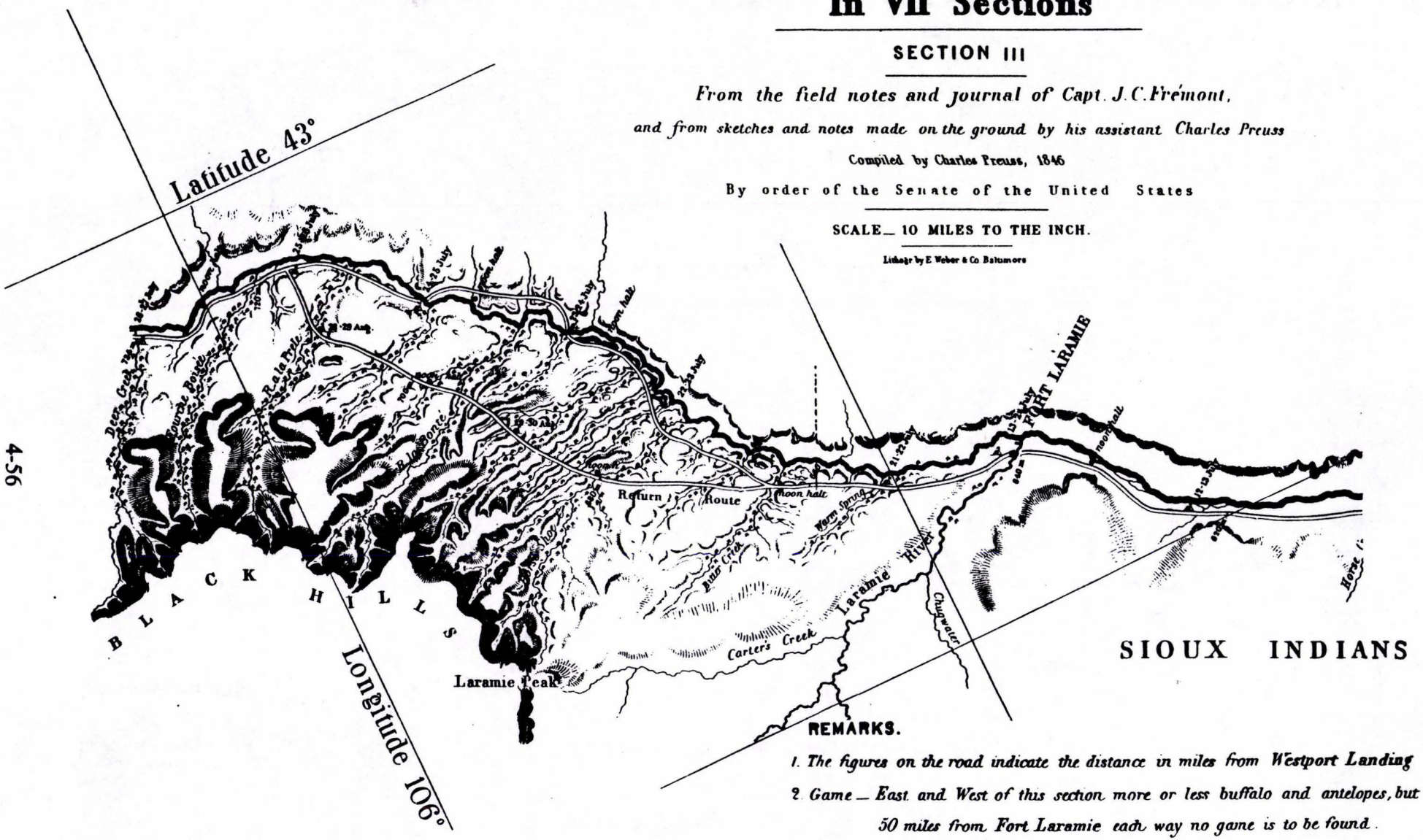

In VII Sections
SECTION III
From the field notes and journal of Capt. J.C. Frémont,
and from sketches and notes made on the ground by his assistant Charles Preuss
Compiled by Charles Preuss, 1846
By order of the Senate of the United States
SCALE— 10 MILES TO THE INCH.
Lithogr by E. Weber & Co. Baltimore
Latitude 43°
Longitude 106°
BLACK HILLS
Laramie Peak
Return Route
Moon halt
Warm Spring
Bitter Cr.
Laramie River
Chugwater
Carter's Creek
FORT LARAMIE
SIOUX INDIANS
REMARKS.
1. The figures on the road indicate the distance in miles from Westport Landing
2. Game — East and West of this section more or less buffalo and antelopes, but 50 miles from Fort Laramie each way no game is to be found.
3. Grass — is scanty and only occures on the banks of the rivers and creeks.
4. Fuel — also scanty. Driftwood, sage bushes, bois de vache and some cotton wood.
5. Indians Good guards ought to be kept all the way. Sioux Indians are not to be trusted.

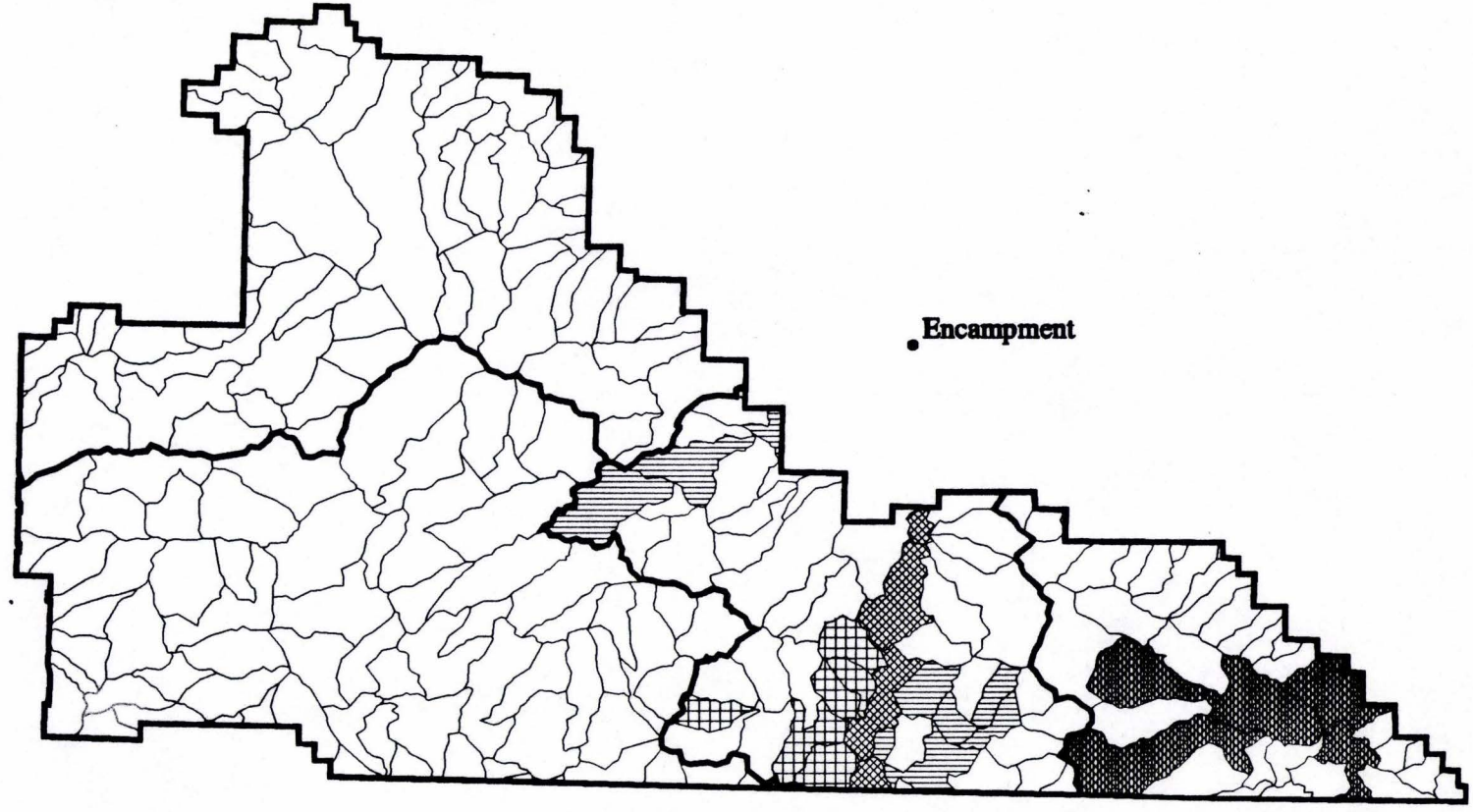
FIGURE 4.3. Fremont's map, from the 1842 expedition, of the Laramie Mountains between Deer Creek and Laramie Peak. 23% reduction. (Jackson, 1970)

MEDICINE BOW NATIONAL FOREST

Watersheds with known Tie Driven Streams

SIERRA MADRES

FIGURE 4.4



LEGEND

Duration of Tie Drive Activity

- Unknown Duration
- 1 - 20 years
- 21 - 50 years
- 51 - 72 years

(Data from Young, 1992, with additions by Medicine Bow N.F.)

- 8th Level Watershed Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

CHAPTER 5

A WALK THROUGH THE MEDICINE BOW NATIONAL FOREST

PHOTOESSAY

This chapter is a pictorial essay showing diversity of landscapes and major ecosystems, land uses, and historical conditions to provide a visual and conceptual framework for subsequent discussions of terrestrial and aquatic biological diversity. Different scales are presented ranging from high-altitude color infrared photographs to low altitude aerial color photographs, landscape views, individual species, and magnified images of mycorrhizae on root tips.

Representative ecosystems, mainly in late successional stages are in Photographs E-1 through E-80. Examples of ecosystems mostly with earlier seral stages resulting from man-caused or natural disturbances are in photos E-81 through E-104. Known or probable effects of disturbances on biological diversity and ecological integrity are indentified. Ecosystems with environmental extremes and repeat photography are in E-105 through E110. Historical photographs and disturbance to aquatic and riparian ecosystems are in the next section. The final section includes aerial photographs and photographs of roots with mycorrhizae.

Photographs are in four groups preceded by a letter:

E = ecosystem photographs
H = historical photographs
A = aerial photographs
M = mycorrhizal photographs

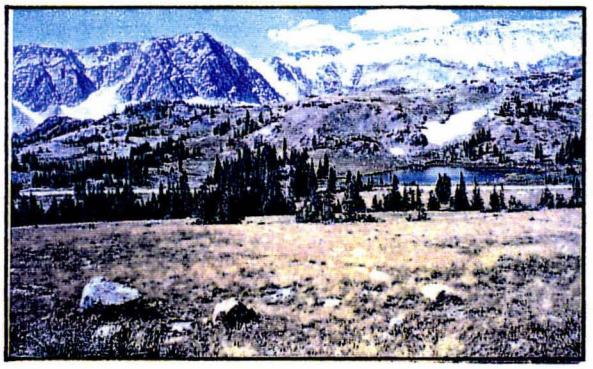
References to these pictures are found throughout the text.

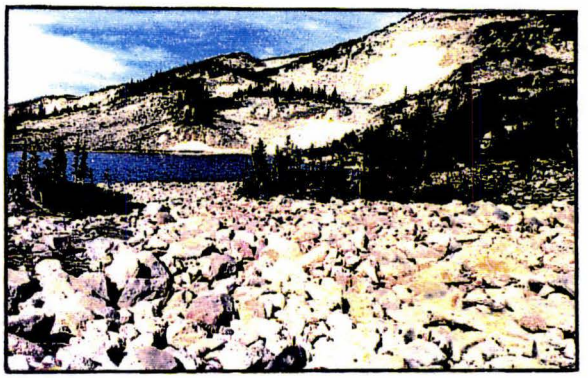
ECOSYSTEM PHOTOGRAPHS (E)

and

HISTORICAL PHOTOGRAPHS (H)

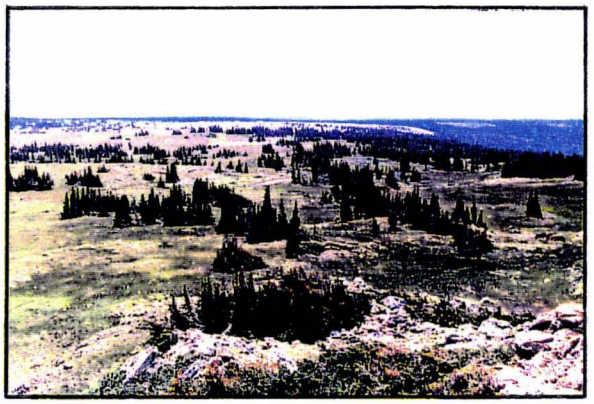
E-1





E-2

E-3



E-4

E-5

E-6

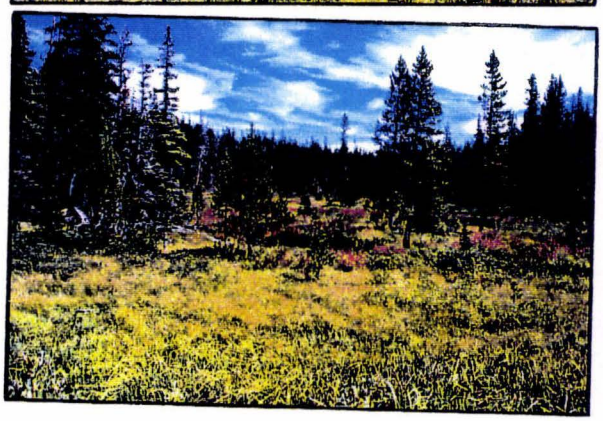
E-7

E-8

E-9

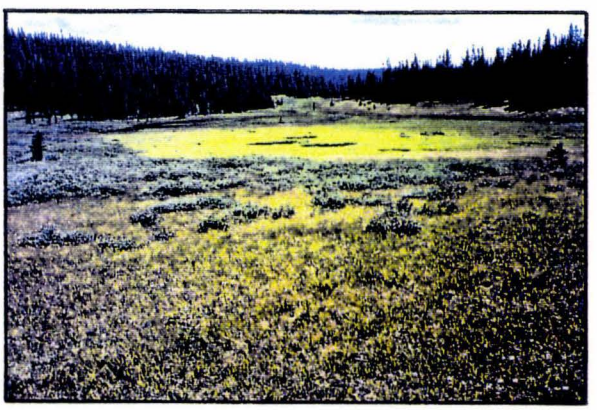
E-10

E-11



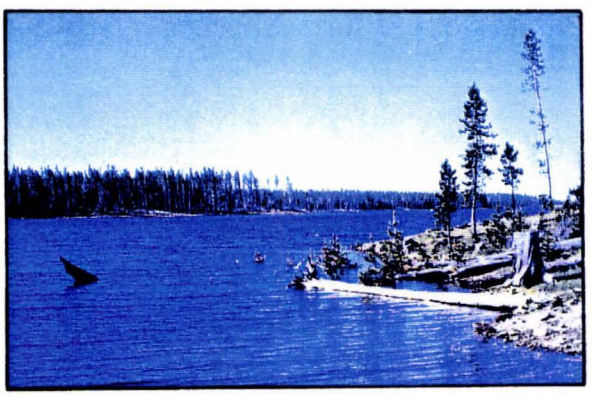
E-12

E-13



E-14

E-15



E-16

E-17

E-18

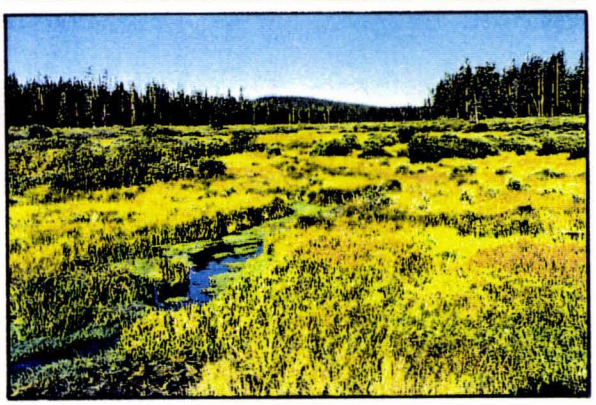
E-19

E-20

E-21

E-22

E-23



E-24

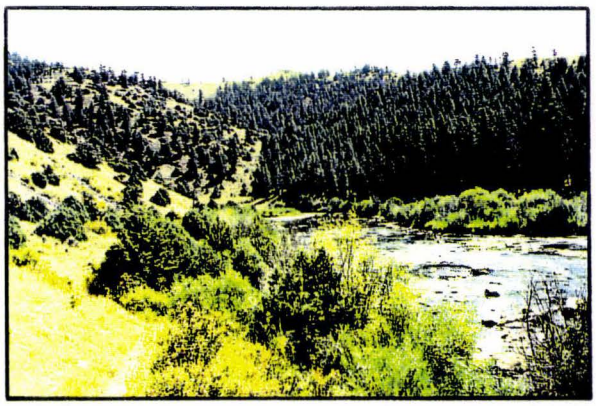
E-25

E-26

E-27

E-28

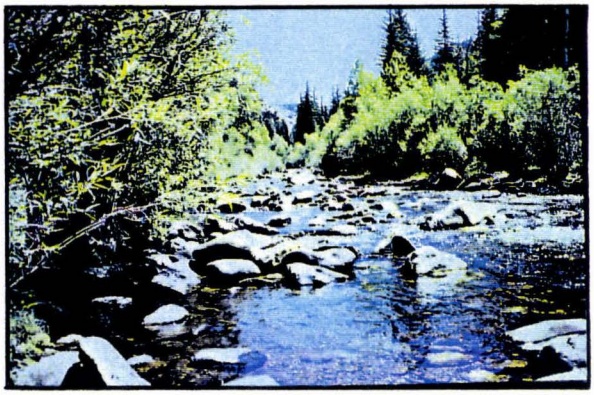
E-29



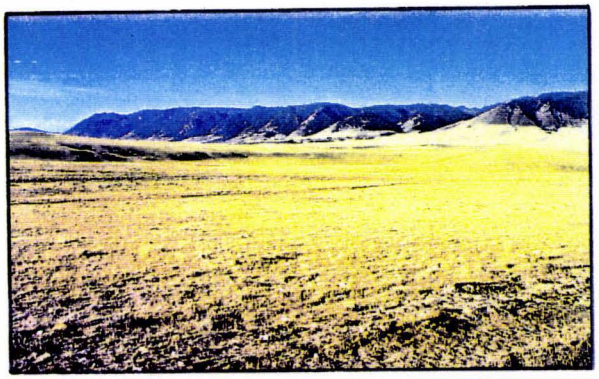
E-30

E-31

E-32



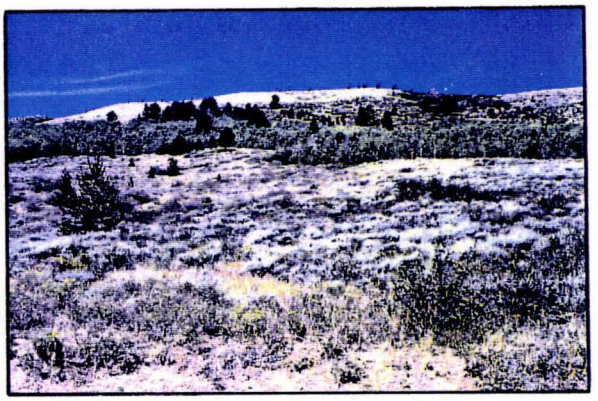
E-33



E-34

E-35

E-36

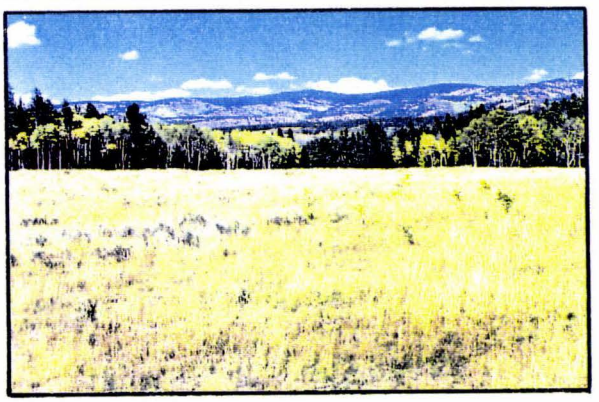


E-37

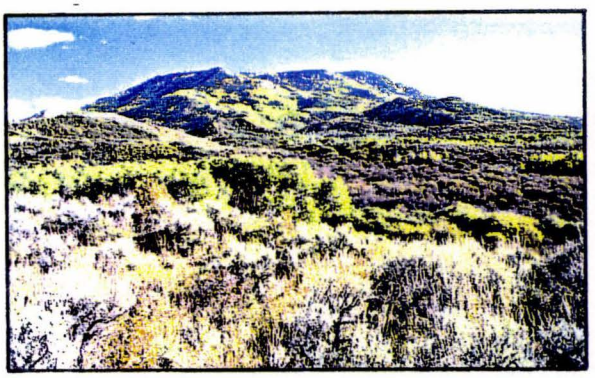
E-38

E-39

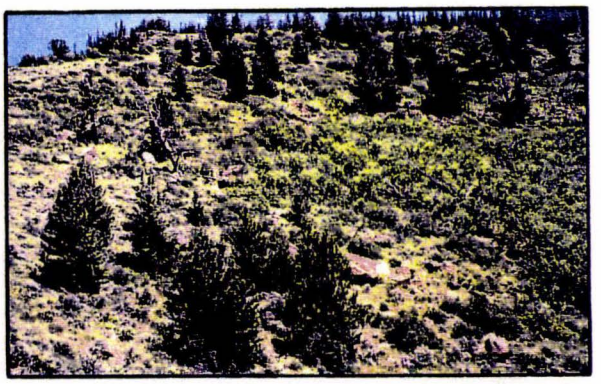
E-40



E-41



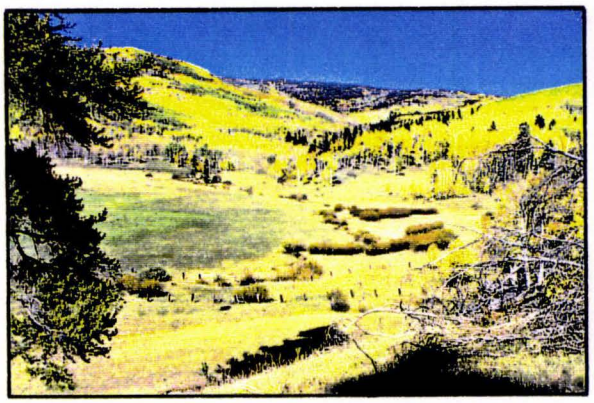
E-42



E-43

E-44

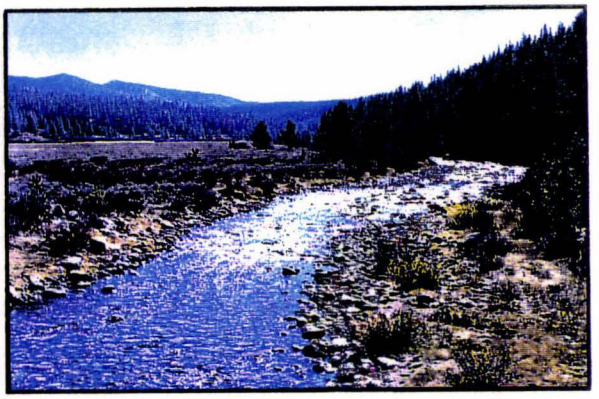
E-45



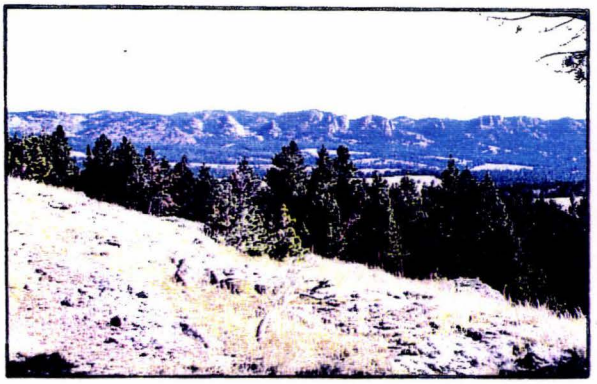
E-46

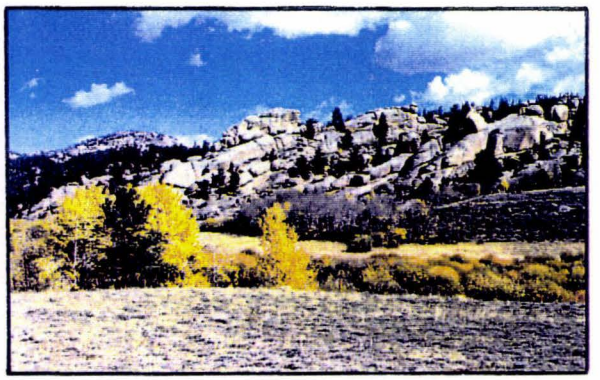
E-47

E-48



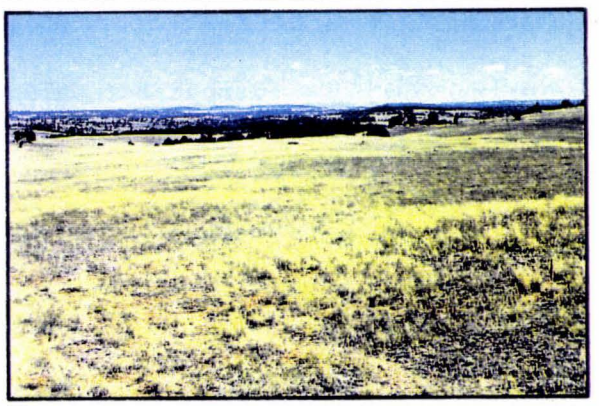
E-49





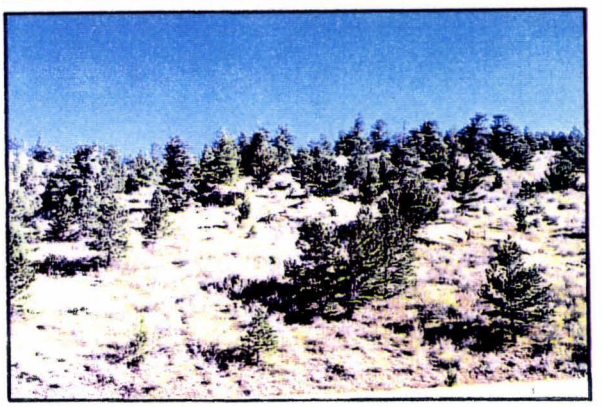
E-50

E-51



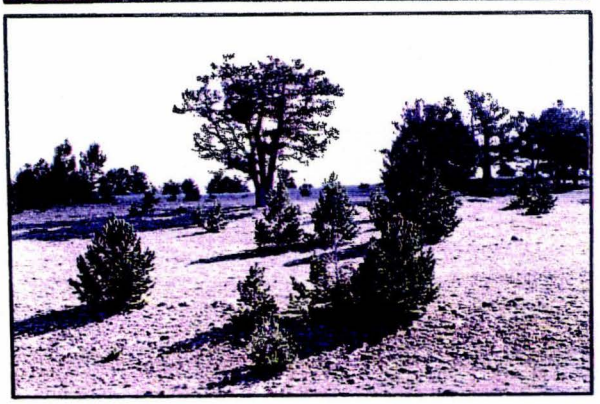
E-52

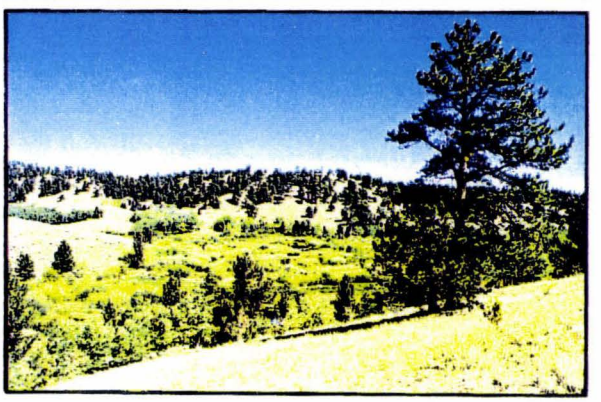
E-53



E-54

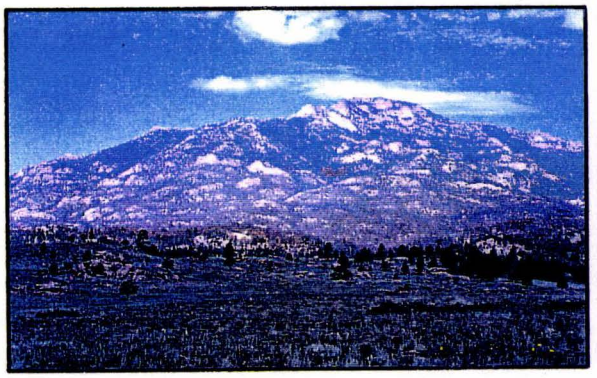
E-55

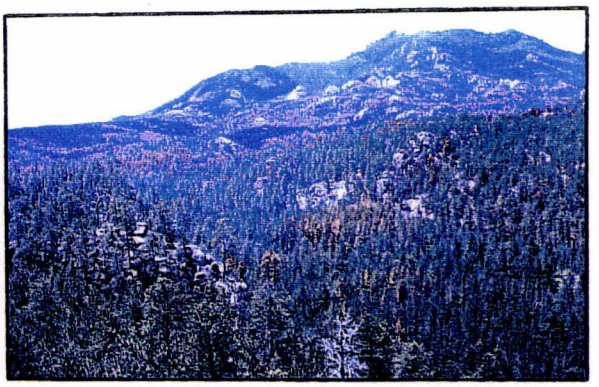




E-56

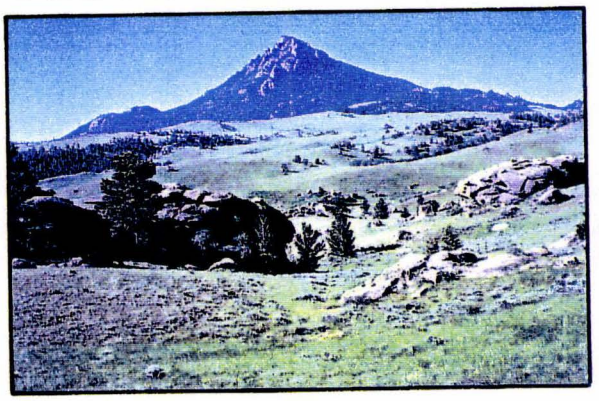
E-57





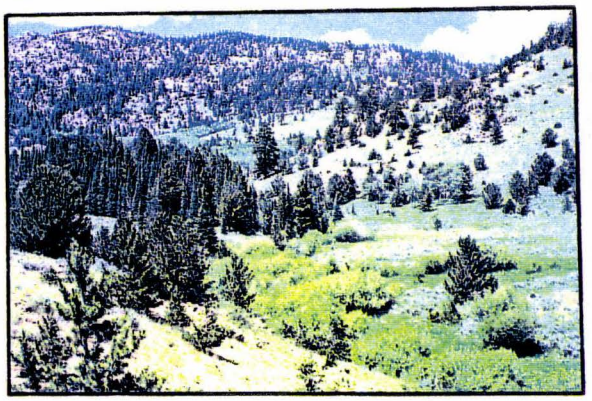
E-58

E-59



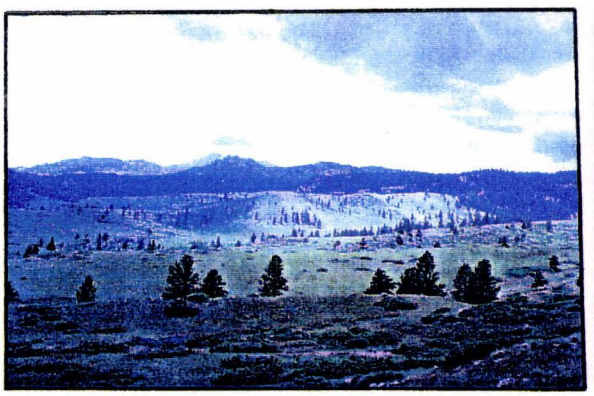
E-60

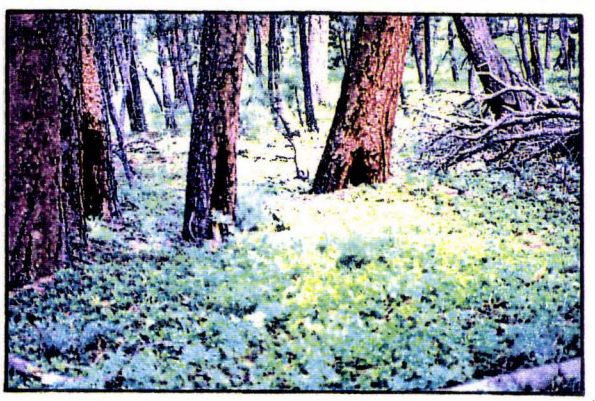
E-61



E-62

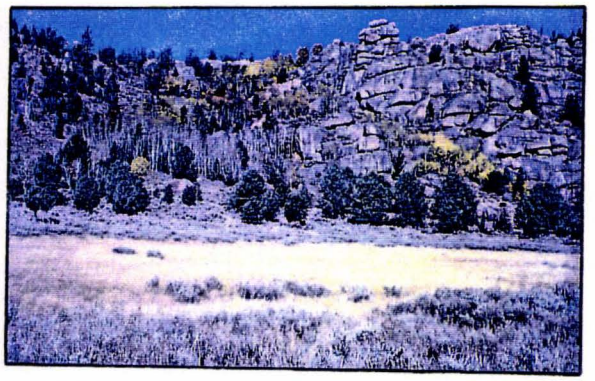
E-63





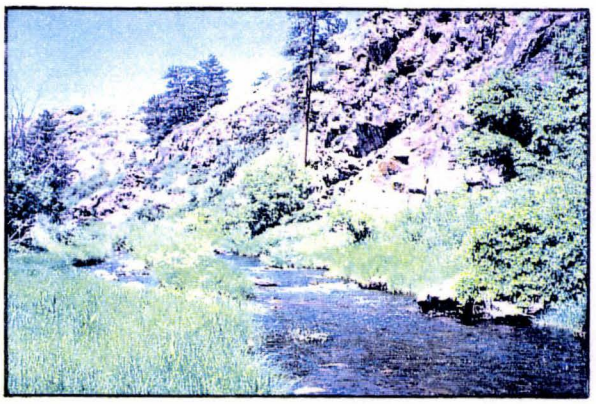
E-64

E-65



E-66

E-67

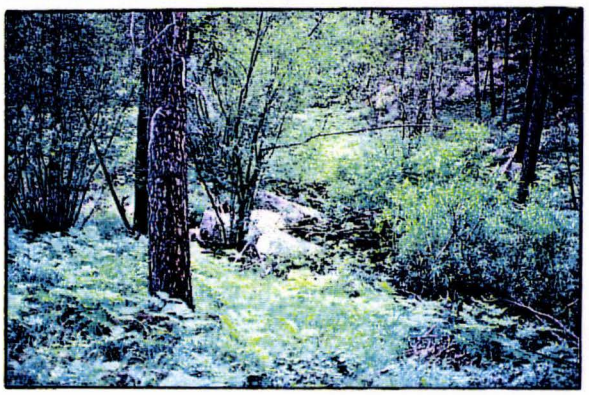


E-68

E-69

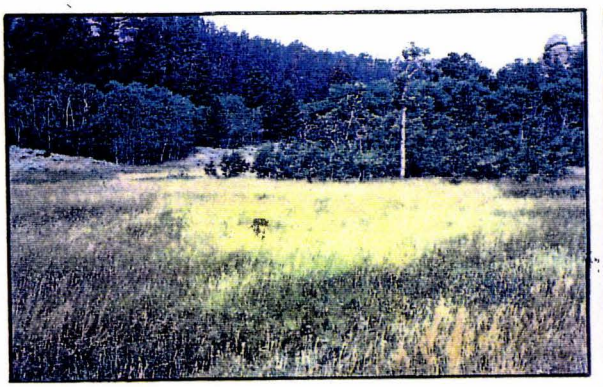
E-70

E-71



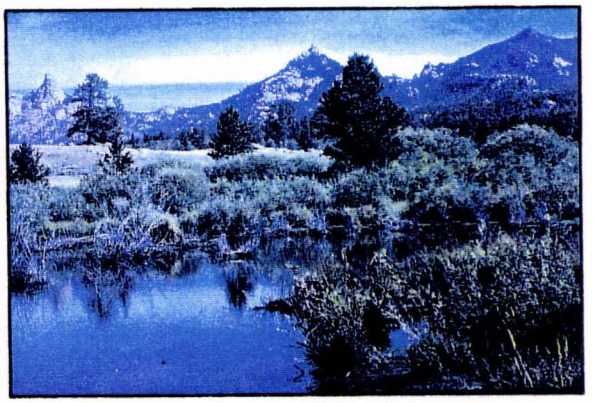
E-72

E-73



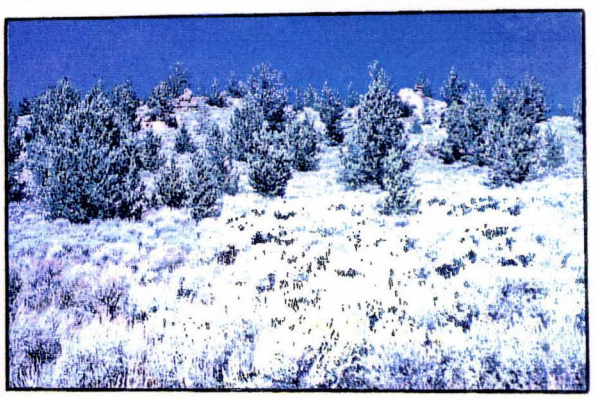
E-74

E-75



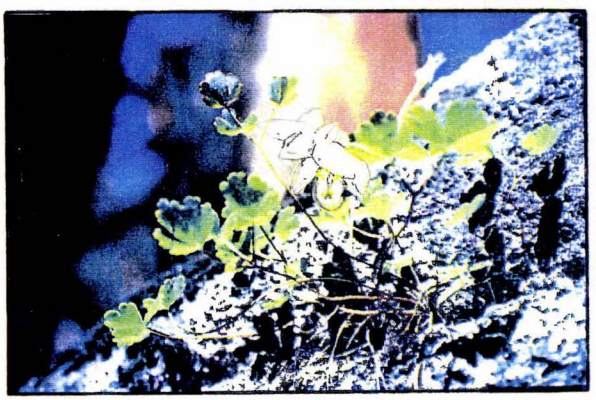
E-76

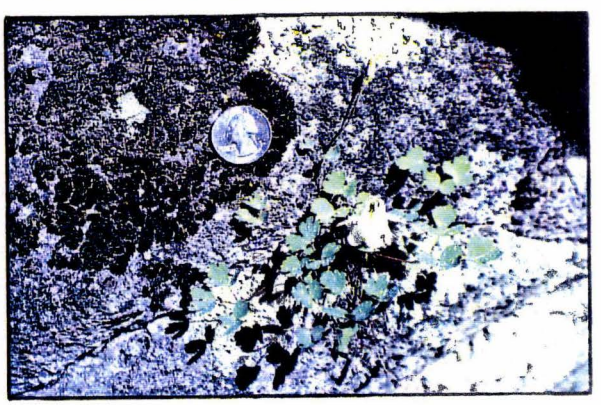
E-77



E-78

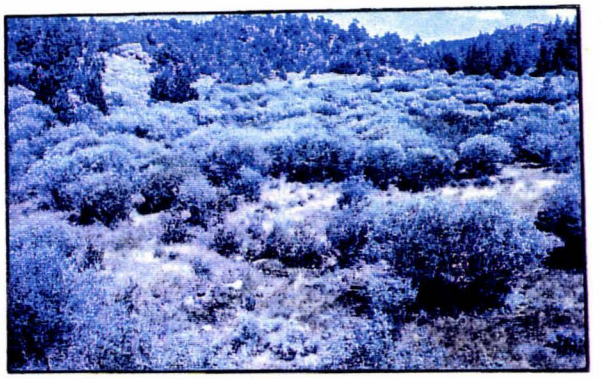
E-79





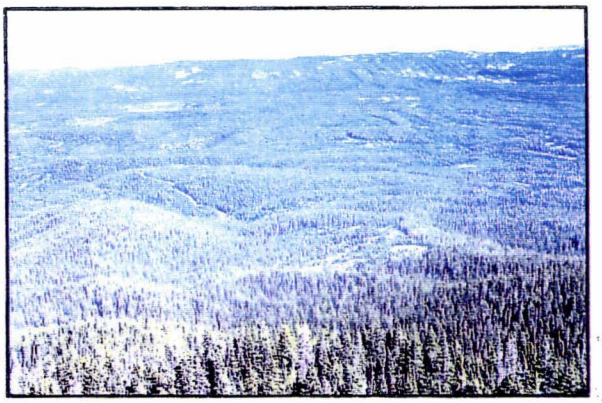
E-80

E-81



E-82

E-83



E-84

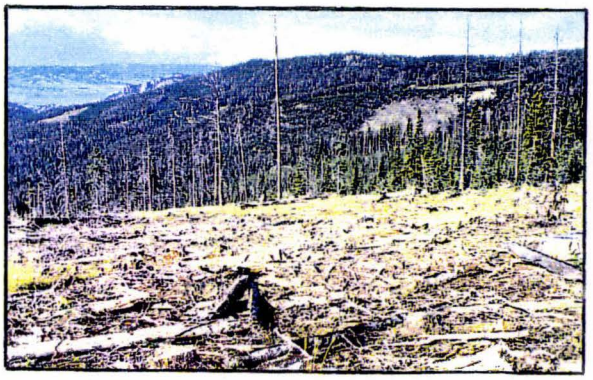
E-85

E-86

E-87

E-88

E-89



E-90

E-91

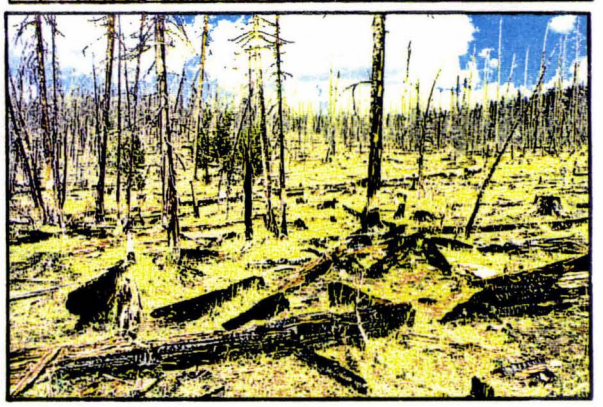
E-92

E-93

E-94

E-95

E-96



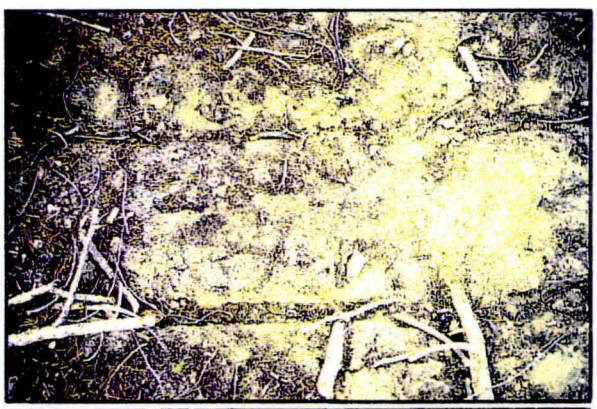
E-97

E-98

E-99

E-100

E-101



E-102

E-103

E-104

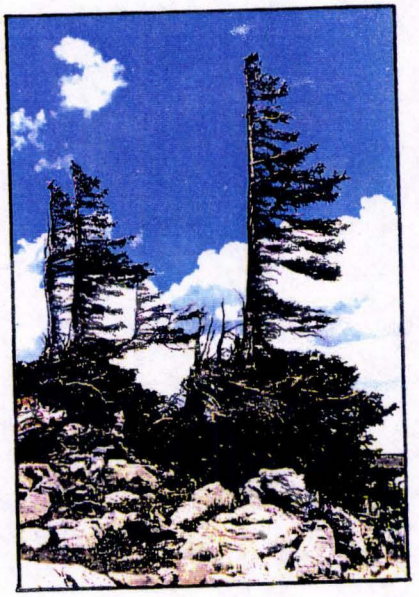
E-105

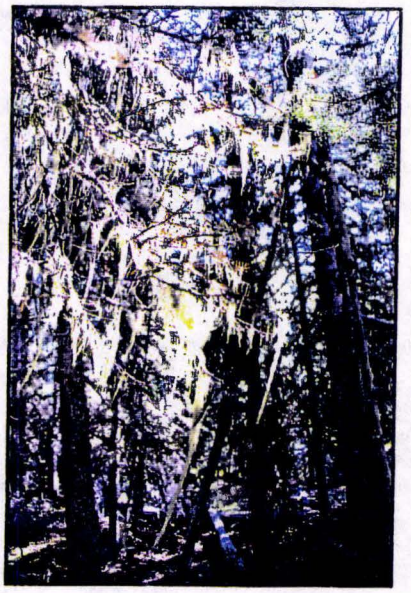
E-106

E-107

E-108

E-109





E-110

MEDICINE BOW MOUNTAINS
DIVERSITY OF ALPINE AND SUBALPINE ENVIRONMENTS

E-1 The rugged, glaciated face of Medicine Bow Peak, glacial moraines at timberline, Bellamy Lake and subalpine meadows with glacial erratics. Bellamy Lake is at 10,600 feet. Medicine Bow Peak, at 12,013 feet, is composed of resistant metasedimentary quartzite rock. Trees are Engelmann spruce and subalpine fir. September, 1993. J. von Ahlefeldt.

E-2 Talus and glaciers at Glacier Lakes Experimental Ecosystems Area (GLEES). These high lakes are filled mainly from glacier meltwater and snow, providing an ideal site to study the effects of atmospheric deposition on lake chemistry and aquatic organisms. Elevation of the lake is about 10,800 feet. July 15, 1994. J. von Ahlefeldt.

E-3 Glacial moraines and ribbon forest on Libby Flats at the head of French Creek. Libby Flats is littered with glacial debris. This high elevation erosional surface, left after Pleistocene glaciers receded, once supported more extensive forests. Today, many trees are dwarfed and deformed by the severe environmental conditions (see E-5). Dead needles and branches resulting from dessication and snow blasting during the dry winter of 1993-94 can be seen in the foreground tree clumps. September 16, 1994. J. von Ahlefeldt.

E-4 Bedrock and old spruce-fir forest at a subalpine lake (Bear Lake) in the Silver Run Creek Creek watershed. Elevation of this lake is about 10,000 feet. Lakes like this and Glacier Lakes are common in the alpine and sublapine area around Medicine Bow Peak. Most formed from large blocks of ice embedded in glacial debris or from terminal moraines which block streams. August 17, 1993. J. von Ahlefeldt.

E-5 Krummholz and banner trees on Libby Flats. Subalpine fir and Engelmann spruce can form roots at branch nodes when the trees are bent by wind and flattened by snow. *Krummholz* is a German word for crooked wood. There are well developed krummholz and banner trees on all open areas surrounding Medicine Bow Peak. Glacial erratics of many different kinds of rock litter the area. September 16, 1994. J. von Ahlefeldt.

E-6 A kettlehole in the Moraine Ponds potential Research Natural Area. Old growth spruce-fir forest grows beyond the fringe of sedges and grasses. This particular group of small kettleholes is at a very high altitude (about 10,400 feet). This high, cold environment affords suitable habitat for postglacial relic plant species. August 5, 1993. J. von Ahlefeldt.

E-7 Large spruce and fir tree boles from a fire about 1809 (Billings, 1969) on moraines near Libby Flats. It has been nearly 200 years since this area burned. Regeneration growth is slow and the effects of wind flagging and death of leader growth on trees is evident. Here wood weathers more than it decomposes, since the environment is too harsh for much bacterial or fungal growth. Long time periods and slow processes characterize forest development at high elevations.

This site is at approximately 10,700 feet along the Towner Lake Road. September, 16, 1994. J. von Ahlefeldt.

E-8 A kettlehole typical of the larger and more numerous kettleholes found in the Turpin Creek and Medicine Bow River watersheds north of Medicine Bow Peak. Most of these kettleholes are at 9000-9600 feet and support a more diverse flora than the type of kettlehole shown in #E-7. Lily pads (*Nuphar*) are common, and grasses and willows may be found along the edges. Kettleholes like these are suitable habitat for boreal toads. Old forests around many of the kettleholes in the Turpin Creek and Medicine Bow River watersheds were clearcut or partial cut from 1950 until the 1980s. September, 1993. J. von Ahlefeldt.

MEDICINE BOW AND SIERRA MADRE MOUNTAINS DIVERSITY OF RIPARIAN ENVIRONMENTS

E-9 Tufted hairgrass meadow, willow and lodgepole pine forest typical of parklike openings in the northern Medicine Bow Mountains. This is at 9000 feet along the Sand Lake Road. Cold air drains from high alpine environments only four miles to the west. Forests surrounding this meadow are presently lodgepole pine, but subalpine fir and Engelmann spruce will replace this in a few hundred years by succession. September, 1993. J. von Ahlefeldt.

E-10 Tufted hairgrass meadow in Fish Creek Park. Kennaday Peak is in the background. This large spring-fed park is at about 9200 feet. Even in very dry years, strong springs keep the water table high. Peat areas which "bounce" when jumped on occur at the juncture of the meadow with the forest where the transition to dry hillside is abrupt. The north end of this meadow is drier and is grazed by livestock, but the southern end is very wet and has probably changed very little since the glaciers receded. This kind of meadow system has a very stable species composition. September 17, 1994. J. von Ahlefeldt.

E-11 A wetter meadow type than shown in #E-9. This soggy ecosystem is part of a gradient from dry to very wet sites found in the high-elevation spruce-fir forests. Lodgepole pine, subalpine fir, and Englemann spruce can all grow on drier microsites among willows and sedges. This site is along Trail Creek near Sand Lake Road at 9800 feet. Such sites provide a reliable water supply from springs. Trees growing near these areas can attain very large diameters. September, 1993. J. von Ahlefeldt.

E-12 Oxbows in the low gradient Medicine Bow River. This valley is broad and flat with fine glacial sands and gravels beneath it. The shallow, slow-moving water supports a luxuriant growth of grasses and sedges. Willows are found along the forest border. The elevation here is about 9100 feet. September, 1993. J. von Ahlefeldt.

E-13 A willow carr in the high subalpine. This very wet ecosystem at the head of Libby Creek has short willows such as wolf willow and alpine subspecies of planeleaf willow. Forb species such as elephanthead, bistort and rosecrown form a mosaic with willows and sedges. September 1, 1994. J. von Ahlefeldt.

E-14 This high elevation riparian area is at about 10,000 feet, just above Sand Lake. Three distinct riparian zones can be seen along the moisture gradient. Deep rooted willows are in drier areas, tufted hairgrass with willow patches is in moister areas, and finally a very wet sedge meadow is evident. Each of these sites has patches of wetter and drier microsites. A dry meadow is evident in the foreground and in front of the trees in the upper right of the photo. July 19, 1994. J. von Ahlefeldt.

E-15 Rob Roy Reservoir (Southern Medicine Bow Mountains). This is a man-made lake created as part of the Cheyenne water supply system. Lodgepole pine forest is typical of the forest ecosystem at this altitude (9400 feet). The forest around Rob Roy Reservoir, which is part of the Douglas Creek watershed, is comparatively young, since most areas have been harvested or burned since 1860. The stump in the foreground indicates that trees can attain large sizes in this area. July 28, 1993. J. von Ahlefeldt.

E-16 Hog Park Reservoir in the Sierra Madre Mountains. This man-made lake is also part of the City of Cheyenne water system. The Continental Divide is in the background. Stream channels, fish populations, and riparian areas below this lake underwent many changes after the dam was built. September, 1994. J. von Ahlefeldt.

MEDICINE BOW MOUNTAINS
FORESTS and LOWER ELEVATION WETLANDS

E-17 Old growth Engelmann spruce forest with a grouse whortleberry (*Vaccinium*) understory. This forest is near Fourlog Park at the southwestern edge of Libby Flats. The elevation is about 10,400 feet. Spruce-dominated forests on glacial till also occur near Brooklyn Lake where trees have been measured at 600-700 years old. Spruce-fir forests are often interlaced with springs and small meadows. August 17, 1993. J. von Ahlefeldt.

E-18 Remnant logs scattered across Libby Flats indicate that a forest like the one shown in #E-17 occupied parts of the Libby Flats area prior to the fire in the early 1800s. August 5, 1993. J. von Ahlefeldt.

E-19 Canopy gap in spruce-fir forest south of Sand Lake. Both Engelmann spruce and subalpine fir of various ages occupy this site at about 10,400 feet. This photo and also #E-20 show gap-phase dynamics where shade-tolerant seedlings grow in gaps formed by disturbance and death of older trees. Disturbances from windthow can be larger. At least two large windthrow events in high elevation spruce-fir forests near Medicine Bow Peak have been documented in the last 150 years. July 19, 1994. J. von Ahlefeldt.

E-20 This old growth spruce-fir forest in the Medicine Bow River watershed is on a colder and wetter site than in #E-20. Lichens and fungi are abundant. The forest is dark and cool. A few large spruce trees tower above the younger spruces and firs which add structure to the understory in addition to the large downed logs. September 2, 1994. J. von Ahlefeldt.

E-21 This lodgepole pine forest has a silver buffaloberry understory. This is common forest type in the southern Medicine Bow Mountains around Foxpark. Cattle grazing has removed most of the forb and grass component, but the shrubs, which are nitrogen-fixers, thrive under the lodgepole pines. August 21, 1994. J. von Ahlefeldt.

E-22 This lodgepole pine forest is 150-200 years old. The understory is a carpet of grouse whortleberry with a few species of grasses, forbs, and lichens. Logs are slowly incorporated into forest soil by decomposition. This forest is at about 9000 feet in the Douglas Creek watershed. On colder sites common juniper is often found in the understory. August 20, 1994. J. von Ahlefeldt.

E-23 Dry meadows covered with timothy (an introduced grass) are common in the southern Medicine Bow Mountains. Several kinds of tall willows are in the wetter parts of the meadow. Sagebrush borders the meadows along the edge of the forest, which may be lodgepole pine, or lodgepole pine with subalpine fir and Engelmann spruce. Spruce-fir forest can develop in the southern Medicine Bow Mountains, but disturbance from logging and fire has produced lodgpole pine forest over most areas. Pelton Creek and WY130. August 20, 1994. J. von Ahlefeldt.

E-24 This wet meadow system in the southern Medicine Bow Mountains is near Foxpark. Willows are abundant and sedges, rushes, and riparian grasses fill the openings. Beavers often colonize these areas. It is also suitable habitat for moose, which are moving into the southern Medicine Bow Mountains from Colorado. Fox Creek. August 29, 1994. J. von Ahlefeldt.

MEDICINE BOW MOUNTAINS - STREAMS AND CANYONS

E-25 A tributary of the North Fork of the Laramie River flows near Sand Lake Road in the northern Medicine Bow Mountains. This stream, at 9000 feet with its wide, shallow bed shows the changes in stream channel structure left from the legacy of tie hacking which lasted from the late 1860's until the early 1940s. Most streams in the Medicine Bow Mountains were affected. These streams carry a high volume of water during spring runoff. Tall willows, with deep roots tapping the underground river, line the edges. Dryland grasses and forbs occupy the rocky gravel and cobble bars adjacent to the stream channel. September, 1993. J. von Ahlefeldt.

E-26 Smith North Creek, near Keystone, is in the southern Medicine Bow Mountains at about 8600 feet. Hydraulic mining and tie driving occurred on this creek and others like it in the past. The smaller stream size and lower gradient is suitable for beaver which have colonized the wide valley now filled with willows. Sagebrush and lodgepole pine forest border this well-defined riparian area. August 30, 1994. J. von Ahlefeldt.

E-27 French Creek Canyon is one of several large canyons carved by glacial meltwater which radiate north, west, and east from Medicine Bow Peak. Libby Creek, the North Fork of the Laramie River, and Brush Creek have similar

geomorphic histories. This is the lower part of the canyon with aspen and sagebrush on the south-facing slopes and conifer forest on the north-facing slopes. A landslide area is visible in the background. Upper slopes of these large canyons were not impacted very much by tie hacking, but they have been harvested in some areas since 1950 by clearcutting or partial cutting. September, 1993. J. von Ahlefeldt.

E-28 Rock Creek Canyon at the northwestern end of the Medicine Bow Mountains is deep and rugged. It carries high volumes of water. This was one of the earliest areas used by tie-hackers because it was near the Platte River at the mountains, and portions of the canyon included flat areas suitable for tie camps. There are many steep, unstable slopes in this canyon area. The upper Rock Creek watershed was the site of large block clearcutting 1965-1976. June 12, 1994. J. von Ahlefeldt.

E-29 The North Platte River Canyon in the southern Medicine Bow Mountains. This low elevation canyon (about 7300 feet) has a mild climate. Juniper woodlands, sagebrush shrubland, and bunchgrasses occupy south-facing slopes, while dense Douglas-fir forest is found on north-facing slopes. There are no major dams upstream on this river which originates in the mountains surrounding North Park, Colorado. Heavy spring flows keep the stream channel disturbed and large cobble and rocks characterize the channel (#E-32). This photograph shows strongly contrasting canyon environments caused by slope exposure and water availability. August 20, 1994. J. von Ahlefeldt.

E-30 This is also the North Platte River Canyon. The diversity of vegetation and habitats in this photograph includes ponderosa pine, lodgepole pine, Douglas fir, and junipers, Idaho fescue meadows, and willow and alder along the stream. August 20, 1994. J. von Ahlefeldt.

E-31 This view of the Platte River Canyon contrasts with #30. This environment is subject to many kinds of disturbance including flooding in the stream channel and narrow riparian areas, periodic fires in the shrublands, grasslands and juniper woodlands, and landslides. August 20, 1994. J. von Ahlefeldt.

E-32 This portion of the Platte River is below the confluence with Douglas Creek, near Pickaroon Campground. Large boulders and youthful riparian vegetation attest to the disturbance frequency and intensity along this riparian corridor. Gallery forests of narrowleaf cottonwood may form an overstory. The Platte River Canyon and associated uplands is one of the most biologically diverse on the Medicine Bow National Forest. It is in a wilderness area and portions of this are being considered for a Research Natural Area. July 28, 1993. J. vo Ahlefeldt.

SHEEP MOUNTAIN, FOREST-PLAIN TRANSITION, SIERRA MADRE MOUNTAINS

E-33 Sheep Mountain is an anticlinal fold which rises abruptly from the Laramie Plains at about 7200 feet to a height of about 9500 feet. The mountain is about

four miles wide and ten miles long. Because of its location and relatively low elevation east of the Medicine Bow Range, it receives only 14-16 inches of precipitation. This is marginal for development of woody vegetation. Sheep Mountain became a Federal Game Refuge in 1924 by Congressional Action. Portions of it are being considered for a Research Natural Area for low elevation bunchgrass, shrub communities, and wetlands. September 1, 1994. J. von Ahlefeldt.

E-34 Lodgepole pine forests on Sheep Mountain grow on soils derived from Sherman granite, a geologic base shared with the Sherman Mountains and the area around Lake Owen in the Medicine Bow Mountains. Soils derived from Sherman granite have low site index values for tree growth. J.von Ahlefeldt.

E-35 Canyons along the sides of Sheep Mountain have aspen groves or shrublands with chokecherry and other shrubs typical of low elevation canyons. Limber pine, lodgepole pine, ponderosa pine, and Douglas fir are the primary conifers, although some juniper, Engelmann spruce, and subalpine fir can also be found. Antelope bitterbrush, sagebrush, and bunchgrasses provide good winter range for big game. May 31, 1994. J. von Ahlefeldt.

E-36 This mosaic of scrubby aspen, sagebrush, bitterbrush, limber pine, and grasses is typical of the ecosystems in the transition from the mountains to the plains. Most areas around the edges of the Medicine Bow Mountains have some remnants of Cretaceous sandstones and limestones and Tertiary or Quaternary alluvium, which add variety to the landscape. September 1, 1993. J. von Ahlefeldt.

E-37 Talus and timberline are found at about 11,000 feet on Bridger Peak, the highest peak in the Sierra Madre Mountains. Bridger Peak was an ice-free area during much of the Pleistocene glaciation. Unlike Medicine Bow Peak, which has polished and rounded rocks from glacial action, Bridger Peak has very hard, sharp rocks. A large variety of lichens is found on these rocks. Ribbon forest, high elevation grassland, and forbland form an open mosaic. This area is used as summer sheep range. Unstable landforms characterize much of the Sierra Madre Mountains. September 19, 1994. J. von Ahlefeldt.

E-38 At the northern end of the Sierra Madre Mountains the Continental Divide ranges from about 11,000 feet at Bridger Peak to about 8000 feet at the National Forest Boundary along the edge of the Great Divide Basin. Block clearcuts are visible to the north (See phota A-1). J. von Ahlefeldt. September 19, 1994.

E-38 This view to the south from Bridger Peak shows the glacial cirque which is home to Battle Lake on the west side of the Continental Divide. A segment of the Battle Highway is visible just beyond the ribbon forest. Large talus fields are at the top of Bridger Peak. The climate of the Sierra Madre Mountains is more like that of the mountains of the Park Range to the south in Colorado than the Medicine Bow Mountains and Laramie Mountains. September 19, 1994. J. von Ahlefeldt.

E-40 This view of Singer Peak in the Little Sandstone watershed shows the gentle nature of the landscape which contains meadows, aspen/conifer mosaics and conifer at higher elevations. The west side of the Sierra Madre has a long history of post-sttlement use involving sheep grazing, fire, timber harvest, and cattle grazing. These warm, low elevation ecosystems have many introduced species such as smooth brome, orchard grass, Kentucky bluegrass, and thistles. September 17, 1994. J. von Ahlefeldt.

SIERRA MADRE MOUNTAINS
SHRUBLANDS, ASPEN FORESTS, AND RIPARIAN ECOSYSTEMS

E-41 Battle Mountain, in the southwestern corner of the Sierra Madre Mountains, is composed of basalt flows and intrusive igneous rocks. This is a different geologic substrate than most of the rest of the area. The top of Battle Mountain at 9100 feet is about 2000 feet above the surrounding landscape. Shrublands of sagebrush and serviceberry form a pitchy mosaic with scrubby aspen on the flanks of Battle Mountain. Lodgepole pine and subalpine fir form small forest patches on top, surrounded by grassland and sagebrush-grassland. The top of Battle Mountain is a potential Research Natural Area for shrubland and bunchgrass systems. September 28, 1994. J. von Ahlefeldt.

E-42 The top of Battle Mountain has limber and lodgepole pine forest patches in a shrubland/grassland matrix. Aspen at the top of the drainage are dwarfed by the harsh, dry, windy conditions. Large subalpine fir grows where the land becomes flat at the top of the mountain. June 10, 1994. J. von Ahlefeldt.

E-43 Gambel oak reaches the northern limit of its range in the lower part of Battle Creek Valley. This extensive fire-adapted ecosystem extends south into Colorado and New Mexico and westward to Nevada and Utah. Battle Mountain can be seen in the background. September 24, 1994. J. von Ahlefeldt.

E-44 The Battle Creek valley was burned in 1841 after a fight between Indians and fur trappers, who had a trading post a few miles to the west. Aspen and shrub communities have developed since. Patches of conifer in the matrix of deciduous trees and shrubs suggest that this area may be in a long cycle of succession back to conifer-dominated systems in the absence of further catastrophic disturbances. September 24, 1994. J. von Ahlefeldt.

E-45 The Roaring Fork of the Little Snake River in the southern Sierra Madre Mountains has a limited willow community in a dry meadow sytem. Aspen currently dominates slopes as a result of fires in the past century but spruce, like the one at the left edge of the photograph would replace the aspen in the absence of fire. September 24, 1994. J. von Ahlefeldt.

E-46 This photograph along the Battle Highway near the Sandstone Work Center shows the process of conifer replacement of aspen as a natural step in succession to conifer-dominated forest. In this process, either lodgepole pine (shown here) or subalpine fir can succeed aspen. This is a common situation over most of the area that was burned in 1841. September 24, 1994. J. von Ahlefeldt.

E-47 These beaver ponds along Hog Park Creek in the southern Sierra Madre Mountains flood this shallow valley, providing habitat for a different suite of riparian species than the high-elevation wetlands found in the Medicine Bow Mountains. These ponds are at about 8000 feet. September 28, 1994. J. von Ahlefeldt.

E-48 The Encampment River heads in the Mount Zirkel Wilderness in Colorado. This river was tie-driven and looks very much like the North Fork of the Laramie River in #E-25. The Encampment River flows north through the Encampment River Wilderness and adjacent areas which have forests of old lodgepole pine, spruce, and fir. September 28, 1994

SHERMAN MOUNTAINS

E-49 The Sherman Mountains are a portion of the Laramie Range. They are formed from uplifted, very old, Precambrian granite. Pole Mountain (elevation 9053 feet), so named because it was a source of poles to build the telegraph lines across the plains in the early 1860s, is in the background. All species of conifer found on the Medicine Bow National Forest can be found in the Sherman Mountains, making this the most diverse area for its size on the entire forest with regard to coniferous trees. September 6, 1994. J. von Ahlefeldt.

E-50 Fractured granite monoliths are a hallmark of the Laramie Mountains. This outcrop along Crow Creek nicely shows the landscape diversity afforded by rock outcrops with ponderosa, lodgepole pine, limber pine, subalpine fir, and Engelmann spruce. Aspen grows on upland areas having springs, or in riparian bottoms. Willows are abundant along the streams and hillsides are covered with grassland or sagebrush. October 3, 1994. J. von Ahlefeldt.

E-51 Pole Mountain, in the background, shows the scale of the mosaic of grassland, shrubland, aspen forest, and conifer forest which characterizes the Sherman Mountains. Conifer forests on Pole Mountain are mostly lodgepole pine, but subalpine fir and Engelmann spruce are also found. Occasional blue spruce occur in canyons. September 6, 1994. J. von Ahlefeldt.

52 Extensive grasslands form a mosaic with ponderosa pine woodland at the north end of the unit. Deposits of alluvium form a shallow substrate over the bedrock and support grasslands on thin soils. Vagrant lichens are extemely common in these systems. These lichens do not attach to substrate (hence the term vagrant) but are caught by their rough edges on rocks or other plants and help protect the soil surface. Environments such as this may have prevented the dispersal of Abert's squirrels (an associate of ponderosa pine) northward to the Laramie Peak area, from northern Colorado, because the forests are too open and scattered to provide suitable habitat. September 6, 1994. J. von Ahlefeldt.

E-53 Thick stands of Douglas fir have developed on north-facing slopes in the absence of fire. Strong winds blowing up Telephone Canyon have caused the trees to lean. This photograph is directly across Interstate 80 from #E-53. October 3, 1994. J. von Ahlefeldt.

E-54 Open ponderosa pine forest with an understory of mountain mahogany grows on a south-facing slope on sedimentary substrates near the Forest boundary along Telephone Canyon. This community type is common in the Front Range of Colorado but unusual on the MBNF in Wyoming, probably because of the scarcity of Cretaceous limestone and sandstone substrates. October 3, 1994. J. von Ahlefeldt.

E-55 Limber pine growing on extremely thin, gravelly soils on a windy west-facing hillside. Limber pine communities are well developed in the Sherman Mountains. Some individuals are very large (30-40 inches dbh). Limber pine communities like this are found in many exposed locations in all mountain areas of the MBNF. October 3, 1994. J. von Ahlefeldt.

E-56 Beavers were reintroduced to the Sherman Mountains in the 1930s. They successfully colonized all streams and encouraged the development of extensive willow carrs. Willow, aspen, sagebrush, grassland and ponderosa pine are the primary species along many of the eastward-flowing creeks. September 6, 1994. J. von Ahlefeldt.

LARAMIE MOUNTAINS

E-57 Laramie Peak is a landmark of the Laramie Mountains. At 10,200 feet, it dominates the landscape above the high plains west of Wheatland, Wyoming. This view from Cottonwood Park (at 6600 feet) taken July 7, 1991, shows the extent of tree mortality caused by the mountan pine beetle epidemic. Large numbers of ponderosa pine near the base of Laramie Peak succumbed. Above about 8000 feet lodgepole pine is more common. The pine beetle did not extensively infest the lodgepole pine forests. Laramie Peak is an extemely rugged mountain with large granite outcrops, deep canyons, and rough talus everywhere. The Laramie Peak area of the Laramie Mountains is essentially a forested island mountain range. Although it is connected geologically to the Front Range, it is somewhat of an ecological island because of the intervening shrublands and grasslands between northern Colorado and the Laramie Peak area. July 7, 1991. J. von Ahlefeldt.

E-58 The Ashenfelder Canyon on the northeast side of Laramie Peak is a proposed Reserach Natural Area for ponderosa pine ecosystems. This photograph, taken July 26, 1991, shows the patchy nature of the mountain pine beetle infestation at that time. Since then, more trees in all age classes have died. Most of the Ashenfelder Basin is virgin ponderosa pine and contains large trees that are up to about 400 years of age. July 26, 1991. J. von Ahlefeldt.

E-59 Most of the Laramie Mountains are partially buried in Tertiary alluvium. This view of Jaybird Peak in the southern Laramie Mountains nicely shows the extensive grassland which surrounds and extends into the Laramie Range. These grasslands are used for summer livestock pasture. Much of the grassland is in private or state ownership, while the peaks are in the National Forest. June 29, 1991. J. von Ahlefeldt.

E-60 This view from Braae Road clearly shows the extensive alluvial deposits with granitic uplifts beyond them. The mountains were formed later than these mid-Tertiary deposits. Terracing caused by livestock is visible in the foreground. June 6, 1991. J. von Ahlefeldt.

E-61 Narrrowly confined riparian areas are characteristic of the Laramie Range. Willows and beaver are found wherever they have not been extirpated by beaver removal, heavy browsing, or trampling by livestock. Hillslopes are typically dry, rocky, and covered with sagebrush, Idaho fescue, and bluebunch wheatgrass. Ponderosa pine is characteristic of the southern Laramie Mountains; limber pine and lodgepole pine are found on the southwestern side; while limber pine, lodgepole pine, and subalpine fir are the most common species at the higher, northern part of the range. This is Gunnysack Creek with open lodgepole pine forest, in the northern Laramie Range. July 1, 1991. J. von Ahlefeldt.

E-62 An area formerly occupied by beaver is shown in this photograph taken near the top of East Prong Green Canyon in the southern Laramie Range. In the past, beavers removed aspen, drowned aspen and conifer trees, and then abandoned the area or were trapped out. Today, an incised stream meanders through hummocky, wet grasslands. Willows are small and heavily used. Subalpine fir is colonizing the riparian area. In the background are many dead trees frm the mountain pine beetle infestation. This photograph shows how ecosystems change. June 24, 1991. J. von Ahlefeldt.

E-63 The area of the Three-Cripples Fire (June 16, 1986). This large fire burned off most of the ponderosa pine forest. Grassland has replaced the forest and patches of regenerating trees are evident. Skunkbrush sumac (*Rhus*) appears in the foreground. Some areas were seeded after the fire with orchard grass, smooth brome, and crested wheat—all non-native grasses. Competition with grasses, trampling from livestock, and climate constraints appear to be limiting ponderosa pine regeneration. The native grass component of Idaho Fescue, bluebunch wheatgrass, slender wheatgrass, and needle-and thread and shrubs such as currant, gooseberry, and wild rose are gone in most areas disturbed by the fire. Adjacent areas were thinned (60 basal feet/acre) in the early 1990s. Much of this area now is a very open forest, also with an understory of non-native grass species and few shrubs. July 11, 1991. J. von Ahlefeldt.

E-64 Old growth ponderosa pines with fire scars in the Ashenfelder Basin. A casual count of fire scars in the Ashenfelder area showed five to eight scars on trees approximately 350 years old, suggesting a mean fire return interval of about 40-80 years. Note the spindly young trees, many of which would not survive a surface fire. The kinninnik understory is one of several common understories found under native ponderosa pine. July 28, 1991. J. von Ahlefeldt.

E-65 LaBonte Canyon, a large canyon along a fault line, has a stream with a high energy disturbance regime caused mainly by summer thunderstorms which cause high runoff from the slickrock in and near the canyon. Flash floods frequently disturb the stream channel. LaBonte Canyon has diverse vegetation, including balsam poplar, wild grape and carrion flower, all of which are atypical in Wyoming. The Canyon is sheltered from the wind and its low elevation (about

6400 feet) confers a warm environment. This canyon was heavily used for livestock for many years, but has been a winter game refuge, with livestock grazing excluded for about 20 years. Exotic species include smooth brome, Kentucky bluegrass, thistle, many annuals typical of disturbed areas, and Siberian peashrub, which was planted near the Curtis Gulch campground. June 15, 1994. J. von Ahlefeldt.

E-66 Upper Deer Creek Canyon in the northern Laramie Range looks similar to the Vedavoo area in the Sherman Mountains. Fractured granite monoliths provide protection to limber pine and lodgepole pine trees. Sagebrush and dry grasslands occupy the high valleys. October 10, 1990. J. von Ahlefeldt.

E-67 In the southern Laramie Mountians the Laramie River flows through a deep canyon rimmed by covoluted granite rocks along fault lines. Most of this warm canyon is sparsely vegetated, but well populated with poison ivy and rattlesnakes. Although the canyon is narrow and steep in some places, there are parts where it is wide enough for terraces to form or for the river to meander, creating debris deposits which support grasslands or even places where residents cut hay. July 17, 1991. J. von Ahlefeldt.

E-68 Dry meadows interspersed in lodgepole pine forest bordered by sagebrush are typical of most high elevation riparian areas in the North Laramie Mountains. This is a very dry, cold ecosystem which affords only a limited amount of herbage production for summer pasture on a small percentage of the landscape. July 14, 1991. J. von Ahlefeldt

E-69 Linear communities of tall willows (commonly Geyer willow, planeleaf willow and Pacific willow) bordered by sedge meadows and confined by dry hillslopes covered with sagebrush, Idaho Fescue, bluebunch wheatgrass and scattered pines are common. Grouse Creek in the southern Laramie Mountains. July 25, 1991. J. von Ahlefeldt.

E-70 In wider valleys, such as Horseshoe Creek in the central Laramie Mountains, extensive willow carrs form. In some areas, beavers have been gone for a long time, but deep-rooted old growth willows persist. July 12, 1991. J. von Ahlefeldt.

E-71 Riparian areas along Ashenfelder Creek have an unusual understory of bracken fern. Thinleaf alder and Pacific willow are two common shrub species, along with red-osier dogwood. This kind of riparian community appears to exist only where there is no livestock grazing. LaPrele means "the fern" in French, and it is possible this kind of riparian vegetation was once more widespread in the Laramie Mountains. Similar community types are known from the Bear Lodge Mountains in northeastern Wyoming. Bracken fern is poisonous to livestock, and it is likely this species has been extirpated from other areas of the Laramie Mountains. June 27, 1991. J. von Ahlefeldt.

E-72 Bracken fern can also grow away from riparian areas on lower hillslopes under mature ponderosa pine. This unusual community type is known from the

Ashenfelder Basin on the Medicine Bow National Forest and also occurs in the Bear Lodge Mountains in northeastern Wyoming. June 27, 1991. J. von Ahlefeldt.

OTHER LANDSCAPES, AND SENSITIVE SPECIES OF THE LARAMIE MOUNTAINS

E-73 Many meadows in the central and southern Laramie Mountains are dominated by tufted hairgrass. Tufted hairgrass is a common species in all high elevation wet meadows on the Medicine Bow National Forest. In some areas this native species has been replaced with timothy, an introduced pasture and haygrass. Tufted hairgrass meadows can also be replaced by Kentucky bluegrass under intensive livestock use. Buffalo Creek. July 23, 1991. J. von Ahlefeldt.

E-74 In the Little Medicine Bow River drainage a sandy substrate occurs beneath a luxuriant growth of bentgrass (*Agrostis* spp.). August 21, 1991. J. von Ahlefeldt.

E-75 Very wet meadows support dense stands of water sedge at higher elevations in the Laramie Mountains. The forest type is subalpine fir and Engelmann spruce. Manse Creek. August 3, 1992. J. von Ahlefeldt.

E-76 Beaver ponds like this were scarce in the Laramie Mountains in 1991-1992. Beavers were found in the Ashenfelder drainage, Arapaho Creek, Friend Creek, south Fork of LaBonte Creek, and some of the tributaries and along the main stem of south Horseshoe Creek. Generally, beaver populations in the Laramie Mountains appear to be low and poorly distributed. This pond is in Friend Park and fills what would otherwise be a deep and eroding gully. September 4, 1991. J. von Ahlefeldt.

E-77 Horseshoe Creek in the southern Laramie Mountains has high volume during spring runoff or during summer thunderstorms. Like LaBonte Creek and Deer Creek, this stream is capable of sudden and severe flooding. July 11, 1991. J. von Ahlefeldt.

E-78 This limber pine/sagebrush community is extensive in the northern Laramie Mountains where it is extermely windy, cold, and dry. October 4, 1990. J. von Ahlefeldt.

E-79 This is the Laramie columbine, an endemic species on the Region 2 Sensitive Species list. It is know only from the Laramie Peak area where it grows in rock crevices. Ashenfelder Basin. June 28, 1991. J. von Ahlefeldt.

E-80 The Laramie columbine is a relative of the Colorado columbine, a much larger species. Ashenfelder Basin, June 28, 1991. J. von Ahlefeldt

E-81 Deer Creek in the North Laramie Mountains flows across bedrock below sediment from a former beaver pond. Removal of beaver from many drainages has created this loss of diversity where open water, shallow water, and associated vegetation such as willows, rushes, and sedges has been replaced by rocky streams with eroding banks. This kind of situation exists pervasively on private, state, and National Forest land in the Laramie Mountains. July 14, 1992. J. von Ahlefeldt.

E-82 Beaver Dam Creek in the Laramie Mountains is also completely devoid of beaver, although suitable habitat is present. The stream is a trickle in the meandering channel in the foreground. The large-deep-rooted old growth willows are able to persist. Dryland grasses and annual forbs occupy the spaces between the willows. Aerial photographs from 1973 show this valley with a series of beaver dams, now gone. August 29, 1991. J. von Ahlefeldt.

E-83 Regenerating block clearcuts up to about 45 years old perforate the once continuous lodgepole pine and spruce-fir forests of the southern Medicine Bow Mountains. Tie hacking and widespread fires changed the forest structure from about 1867 until fire suppression became effective after 1910. Since then, few fires have burned in the Medicine Bow Mountains. The major disturbance process now which affects pattern and age structure is timber harvest. View is northwest from Spruce Mountain Fire Lookout. July 28, 1993. J. von Ahlefeldt.

E-84 Strip cutting is another type of clearcutting, practiced mainly on the higher elevation forests of the Brush Creek District in the northern Medicine Bow Mountains from about 1950-1975. It was used during this time because research showed that this pattern best reduced losses from blowdowns and allowed regeneration in spruce-fir forests. View is to the south from Kennaday Peak. Extensive areas of both lodgepole pine and spruce-fir forest were harvested using this silvicultural method for about 25 years. September 12, 1994. J. von Ahlefeldt.

E-85 Engelmann spruce and subalpine fir are slowly recolonizing large block cuts along the north-facing side of French Creek. These clearcuts from 1971 are at about 10,300 feet. They are slowly regenerating to the original forest type. The parent forest consisted of mainly spruce trees about 200-250 years old. Adjacent uncut spruce forest has a very sparse understory in contrast to the thick growth of grasses, rushes, sedges, and forbs in the clearcut. Clearcuts done at the same time, in lodgepole pine forests at lower elevations, would typically have lodgepole pine trees about the height of the fir tree at the right of the photograph. August 30, 1994. J. von Ahlefeldt.

E-86 Riparian areas are intimately intermingled with many high elevation spruce-fir forests in the Medicine Bow Mountains. In upper French Creek, riparian spruce-fir forest was harvested. Many trees were defective and left piled on the site. The

brown forb is arrowleaf groundel (*Senecio triangularis*) which only grows in wet sites. Areas such as this provide some additional forage for sheep or cattle, but regeneration is very slow and poor, so in a time frame of a century or possibly more, this kind of harvest amounts to a type conversion of forest to grassland. Silver Lake Sale. Road 260. September 9, 1994. J. von Ahlefeldt.

E-87 There are many kettleholes in the northern Medicine Bow Mountains on the Brush Creek District. Most are in the Turpin Creek and Bow River drainages at 9000-9600 feet. Since kettleholes are typically associated with rocky moraines, there is little saturated area associated with them. Consequently, it was possible to take logging machinery to the edges of kettleholes as well as on moraine ridges between them. Many acres of kettlehole ecosystems have been impacted by clearcutting from 1950 to the early 1980s. (See photo A-4.) Kettlehole areas are now considered to be riparian areas and special timber harvest methods are used. Boreal toads, a Region 2-Sensitive species, is found in kettleholes. Forest will regrow slowly on previously harvested areas because of rocky, morainal soils. This photograph was taken near Firebox Lake on the Laramie District where there are a few small kettleholes. September, 1994 . J. von Ahlefeldt.

E-88 The 1968 Bow River blowdown area on the Brush Creek District is at about 10,000-10,500 feet. The blowdown was a natural event. The area was salvage-logged. The light green shrubs are elderberry plants. This species was also observed in clearcuts along French Creek Ridge. Regeneration patterns following salvage logging of this blowdown at 9600-10,600 feet are very similar to the clearcut. September, 1993. J. von Ahlefeldt

E-89 Clearcuts of various ages in mixed late-seral lodgepole and spruce-fir forest in upper French Creek. The two to three year old clearcut in the foreground has been roller-chopped. Clearcuts in the background are ten to 20 years old. These will be young forest patches in a matrix of old trees forest. A high patch density of clearcuts will produce patches of old forest in a matrix of younger forest. The patch size from stand-replacing disturbance due to individual clearcuts is smaller than what is expected from canopy fires. Canopy fires would be expected in high elevation forests no more than every 200-700 or more years. The cumulative patch size of young vs old forest may be closer to what could be expected for natural disturbance, but the pattern is likely different. There is no existing data for patch size due to fire disturbance for high elevation forests on the MBNF. September 1, 1994. J. von Ahlefeldt.

E-90 A recent (1991) rollerchopped clearcut in lodgepole pine near Gramm. Cattle are permitted to graze on clearcut areas seeded with grasses and forbs for wildlife food, erosion control and livestock food. Grazing is monitored but the long and short-term effects of grazing on succession and species composition are not known. Grazing during early succession may result in less plant vigor and persistence of less palatable species. August 28, 1994. J. von Ahlefeldt.

E-91 A blowdown in the Cedar Creek watershed in June, 1987. This photograph illustrates the kind of process in lodgepole pine stands which thins stands over

time and provides woody debris inout to the forest floor. September 12, 1994. J. von Ahlefeldt.

E-92 This is part of the same blowdown area shown in #E-90, but it was salvage-logged. Young pines are regenerating in the cleared area. Some woody debris has been left on the site, but the amount and distribution is different from the natural blowdown. Microclimates affecting decomposers will be sunnier and windier until the canopy closes in about half a century. September 12, 1994. J. von Ahlefeldt.

E-93 This photograph shows a 1960s clearcut (left), a 1980s clearcut (right) and an uncut forest (background) (see #E-22). The large fir trees in the 1960s clearcut with a lot of woody debris, characterize the cutting practices used in the 1960s. In the 1980s less woody debris was left on the site, submature fir trees were not left, but a few snags were included in the prescriptions. Monitoring is recommended to evaluate the differences in biological diversity in clearcuts left by different post-harvest practices associated with clearcutting. August 30, 1994. J. von Ahlefeldt

E-94 This site in the Sierra Madre Mountains was rollerchopped in Fall of 1994. The large slash pile will be burned. Rollerchopping damages or destroys crowns of shrubs such as *Vaccinium*, common juniper, and silver buffalo berry. It also disrupts cryptogamic soils (lichen crusts) which are found under dry lodgepole pine forests in dry areas at lower elevations. The need for rollerchopping for tree regeneration, its biological diversity costs and benefits and its effects on succession needs to be evaluated and monitored. September 7, 1994 J. von Ahlefeldt

E-95 This site was tie-hacked before the turn of the century. A fire destroyed the regenerated stand in 1910. These trees are a third generation of lodgepole pine. Along Road 206 near the intersection with Road 225 at the bottom of French Creek Canyon. August 30, 1994. J. von Ahlefeldt.

E-96 This is the result of a canopy fire on Smith North Creek, south of Savage Run Wilderness. This fire burned young lodgepole pine on the hillside and larger trees in the riparian area. Note the patch of lodgepole pine missed by the fire. Some structural differences between fires and clearcuts include overall patch size, internal patchiness, standing trees and amount of soil disruption (compaction and ripping). Fire intensity is always variable within a burn, but clearcut treatments tend to homogenize areas. Effects on nutrient status and modification of microclimate are also different, but more difficult to measure. August 30, 1994. J. von Ahlefeldt.

LANDSCAPE PATTERNS, AND LICHENS

E-97 This view is to the west directly toward Kennaday Peak from Rock Creek Ridge. The limber pine forest in the foreground has cryptogamic soils below it. Lichens are holding the soil in place in this very windy location. Five landslide areas are evident in the Rock Creek Canyon drainage. Most of the forest in the

background is virgin lodgepole pine 100-300 years old. An exception is the lighter green patch below the landslide in the upper center of the photograph. This is from a fire in the 1880s. Several clearcuts are evident on ridgetops. The Sand Lake Road is visible as a horizontal slash in the upper left. September 5, 1994. J. von Ahlefeldt.

E-98 This view of the north face of French Creek Canyon includes two of the 1971 clearcuts visible from Snowy Range Road. The anvil-shaped dark area connected to the old spruce-fir forest along the top of the ridge is an area spared by a fire in 1830 which burned most of the rest of the north side. The valley has regenerated to lodgepole pine now about 150 years old. September 1, 1994. J. von Ahlefeldt.

E-99 These lichens and mosses of closed-canopy forests colonize decaying wood and help provide conditions for other organisms of decay which incorporate wood into the forest soil. Lichens are not found where the canopy has been thinned or removed. Lichens can also be removed by fire. August 28, 1994. J. von Ahlefeldt

E-100 These are lichens of the genus *Cladonia*. They are found on rotting wood being incorporated into the forest floor. They must have cool, moist, shady conditions to establish and persist. Lichens are eliminated from clearcut sites and survive poorly in partial cut areas. Loss of lichen flora, mosses and invertebrates for an undetermined length of time is one of the most pervasive impacts to biological diversity of timber harvest. August 29, 1994. J. von Ahlefeldt.

E-101 Rollerchopping, which exposed bare mineral soil at this site near Gramm in 1994, disrupted the cryptogamic crust formed by lichens and forest litter. Even though a rough surface with woody debris was left, fine particles of soil are eroded by the wind. Soil-binding lichens do not begin to recolonize sites like this for at least 40 years, when mosses also begin to appear. It takes a long time for these slow-growing organisms to reach the condition found in a 200+ year-old forest. August 25, 1994. J. von Ahlefeldt.

E-102 Tires of heavy equipment driven over these forest soils damaged, but did not completely eliminate, the mosses and lichens. Kennaday Peak area. September 12, 1994. J. von Ahlefeldt.

E-103 *Stereocaulon tomentosum* is an attractive lichen of old growth forests. This specimen from the Platte Ridge Wilderness is about six inches in diameter. Lichens are a poorly known component of biological diversity. August 23, 1994. J. von Ahlefeldt.

E-104 This is a cryptogamic crust, composed of lichens and mosses, which cover the forest floor in dry lodgepole pine forests. Cryptogammic crusts are found in dry ecosystems throughout the western United States. They protect, build, and enrich soil. Sensitive crusts such as these are subject to damage by trampling, heavy equipment, and rollerchopping. Foxpark area. August 28,1994. J. von Ahlefeldt.

REPEAT PHOTOGRAPHY AND ENVIRONMENTAL EXTREMES

E-105 This photograph taken of Medicine Bow Peak in 1938 includes some of the same landscape as photo #E-1. Bellamy Lake is at the right edge. The photo clearly shows where drifts form in this timberline area. 1938. Ralph Espach.

E-106 This 1992 repeat photograph of E-105 shows how trees have increased in number and density since 1938. The tree pattern is controlled by, and controls, drift formation. 1992. Ralph Espach. 1992.

E-107 Mirror Lake in 1937. Fire had partially removed forest on the far side of the lake. 1937. Ralph Espach.

E-108 Mirror Lake in 1992 showing the increase in subalpine forested area, grasses, forbs and krummholz in the half century since the photo in #E-106 was taken. 1992. Ralph Espach.

E-109 Banner trees and krummholz of Engelmann spruce - effects of the harsh timberline environment. September 16, 1994. J. von Ahlefeldt.

E-110 Engelmann spruce in a protected old growth forest environment where dead lower branches are colonized by lichens of the genus *Usnea* and *Bryoria*. *Usnea* contains blue-green bacteria which fix nitrogen. Both species are found only in old forests. Both are absent from partial cut areas of spruce-fir forests. Photos E-109 and E-100 show the extremes of environment tolerated by spruce-fir ecosystems. September 17, 1994. J. von Ahlefeldt.

H-1 The Keystone post office and Keystone Creek about 1890. Fires near mining and logging centers were common and there was utter disregard for riparian and aquatic ecosystem protection. Courtesy of Lynn Benson

H-2 Another view of Keystone about 1890. The tall stumps are evidence of tie hacking, where trees were cut at snowdepth in winter. Courtesy of Lynn Benson.

H-3 Tie drive operation along Douglas Creek. Hundreds of thousands of ties were transported like this from the late 1860s until 1940. Large log jams like this were common and often required explosives to clear the channel. Medicine Bow Collection - American Heritage Center University of Wyoming

H-4 Ties are decked in the riparian area along Douglas Creek for transport during high spring runoff. Medicine Bow Collection American Heritage Center University of Wyoming

H-5 Tie hackers along South French Creek in the 1890s. Often trees were removed from areas immediately adjacent to the stream as shown by the large stump. Trees 11-16 inches dbh were used for ties. Courtesy of Lynn Benson

H-6 Prior to tie drives, boulders and large trees were removed from channels. Beaver dams were considered a hindrance to tie drives. 1890s. Courtesy of Lynn Benson.

H-7 Hydraulic mining for gold, on Douglas Creek near Keystone, in the 1890s created massive erosion and deep gouges in forest soils. Note the flume near the top of the picture which created pressure for the hoses operated by men in the foreground. Courtesy of Lynn Benson.

H-8 Hydraulic mining of a tributary to Douglas Creek, near Keystone in the 1890s. Material aggraded below beaver dams in the valley floor was washed away, exposing boulders and bedrock. Courtesy of Lynn Benson.

H-9 Splash dams were used to build up a supply of water on small creeks for tie drives. This old splash dam is on Horse Creek, tributary to Douglas Creek. The channel has healed and become narrow and deep with a thick growth of sedges stabilizing the banks. 1991. Lauren Meyer.

H-10 Tie driven streams, rather than being swift, narrow and deep, have wide, shallow channels with even-aged stands of conifers on adjacent slopes. Douglas Creek, 1991. Lauren Meyer.

H-11 This failed splash-dam structure has created an erosion pocket along Smith-North Creek in the Medicine Bow Mountains, It is an example of how historic logging practices still impact streams on the Medicine Bow National Forest. 1990. Marc Wilcox.

H-12 Mine tailings are a source of sediment for stream systems. Extensive mining activity occurred on Douglas Creek, evidenced by these tailings piles. 1990. Paula Guenther.

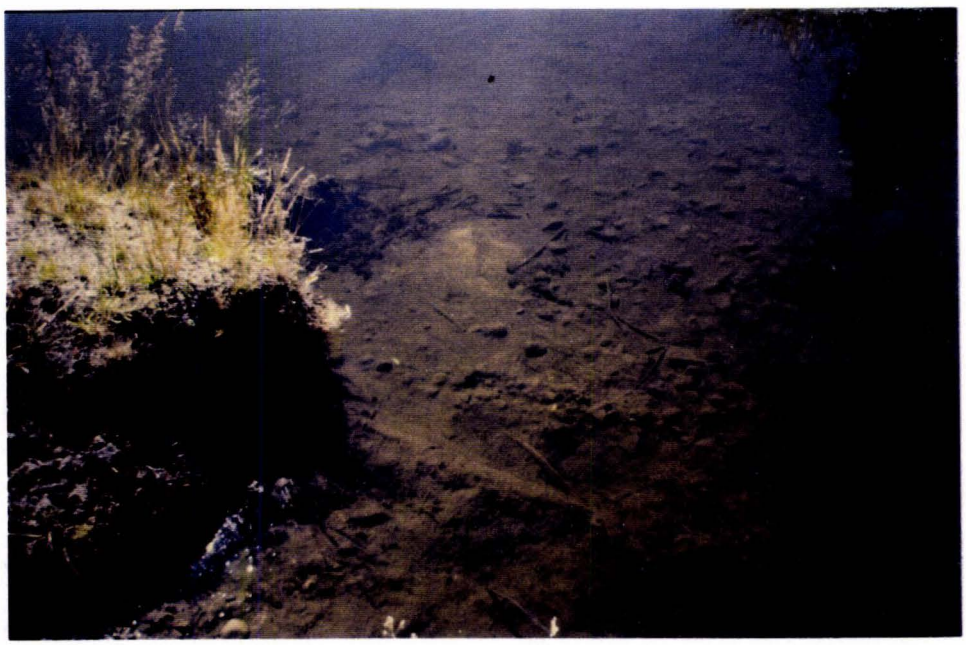
H-13 Point bar formation is an aggradation process caused by excessive sediment loads in streams. This sediment, along Elk Creek in the southern Medicine Bow Mountains, came from a logging road that crossed the floodplain, dating from tie-hacking days. 1994. Clay Speas.

H-14 Excessive sediment accumulation in Pass Creek contributed to the formation of mid-channel bars and altered aquatic habitat. 1994. Clay Speas.

H-15 Numerous, large, sediment introductions into streams on the Medicine Bow National Forest have occurred as a result of construction and operation of Stages I and II of the Cheyenne Water Project, between 1983 and 1993. These erosional and sedimentation events have caused aggradation in stream channels and reduced habitat quality and quantity for endangered Colorado Cutthroat trout. This spill is on Green Timber Creek in the southern Sierra Madre Mountains. 1988. Marc Wilcox.

H-16 The Stage II Water Diversion Project, which brings water from the Colorado River drainage to the North Platte drainage, beneath the Continental Divide, has adversely impacted aquatic habitats on many streams in the North Fork of the Little Snake River. This "blowout" occurred along Deadman Creek in 1984. Marc Wilcox.

H-17 A 1988 sediment spill on Green Timber Creek deposited a thick bed of gravel sediments in Green Timber Creek (compare to H-15). 1988. Marc Wilcox.



H-18 The same sediment spill, in 1988, deposited an excessive amount of fine sediments in Green Timber Creek. 1988. Marc Wilcox.

AERIAL PHOTOGRAPHS (A)

and

MYCORRHIZAL PHOTOGRAPHS (M)

Note: Colors of infrared photographs (A1-A6) are interpreted as follows: white to light blue - areas of high reflectance (clearcuts, soil, rock, roads); Black - water; dark brown - dense forest; red - wet areas (meadows, aspen forests or riparian areas). Some photographs have a "hot spot" (light area) in the upper left corner which dilutes the colors.

A-1. Regular-edge block cuts, 2-3 step shelterwood and group selection cuts.

Rock Creek watershed.

These large block cuts were done between 1966 and 1975. The forest matrix is late-seral lodgepole pine and spruce-fir. Much of the forest matrix between clearcuts was silviculturally treated with 2-3 step shelterwood cuts, resulting in a thinning of the canopy. Forest matrix origin dates (RIS database) range from 1728 to 1815. Most of the stands are at least 200-250 years old. The riparian area in the lower right-hand corner is Trail Creek (A), the upper one is the Middle Fork of Rock Creek (B). Group selection cuts (cluster of small er cuts) are in a stand of spruce dated 1834. Only the very dark patches represent uncut, dense, closed canopy spruce-fir or late seral mixed conifer. This area has small kettleholes (upper left) which are both within the clearcuts and in uncut forest. Photo E-87 was taken about 1/2 mile east of this area.

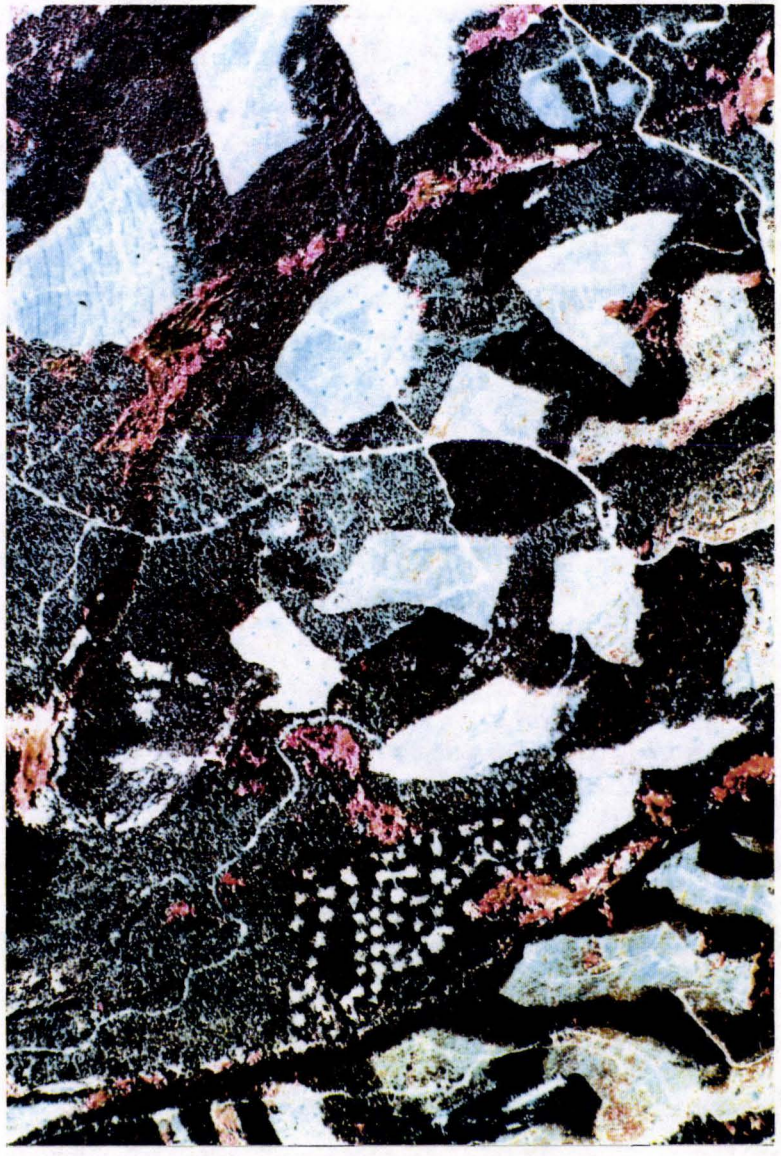
Color Infrared Photograph #2961-36 August, 1989 T17N R79W

A-2. Strip cuts, ribbon forest, kettleholes, wetlands and old growth forest

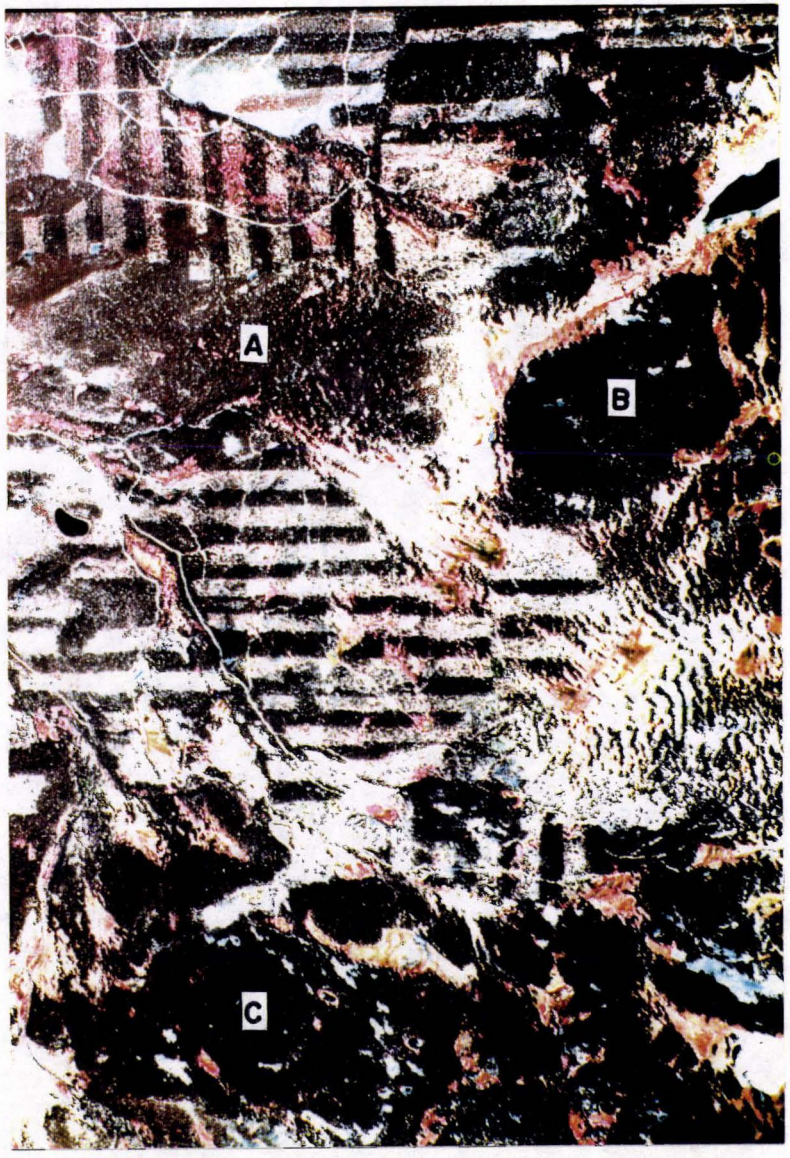
Rock Creek and Medicine Bow River watersheds (eastern part is in potential ribbon forest Research Natural Area)

Three large uncut areas of different ages are evident. A is mostly lodgepole pine dating from the mid-1800s (1860-1899). B is spruce-fir from the late 1600s and early 1700s and C is spruce-fir from the early to mid 1800s. Area C has large kettleholes. Wet meadows are found throughout the area. Ribbon Forest dates from the 1850s. Sand Lake is visible in the upper right hand corner. Strip cuts were done from the 1957 to the early 1980s, mainly in forests with stand orgin dates from the late 1700s to the early 1800s. Area B is one of the largest uncut old forest patches on the Medicine Bow.

Color Infrared Photo 2953-17 August, 1989 T17N R80W



A-1



N

A-2

A-3. Strip cuts, group selection cuts, block clearcuts and natural geologic disturbance

Kennaday Peak

This photograph of Kennaday Peak shows the grassy area at the top, the Cedar Pass Road (#261) and the road to the Kennaday Peak Fires Lookout. Strip cuts on the southeastern slopes of Kennaday Peak were done from 1955 to 1987. Group selection cuts were done later. The forest matrix here is from the mid to late 1700s and is predominantly spruce-fir. The large block cuts on the NE slope were done in 1971. The mass of uncut spruce-fir forest on the north-facing slopes of Kennaday Peak above the Cedar Pass Road dates from the early 1700s with some patches from the early 1800s. Most of the forest on the west side of Kennaday Peak is younger than 1840. Aspen is common (red color below the Cedar Pass Road . Springs are common and patch shape and sizes suggest that fires in the late 1800s were responsible for much of patters seen here. The large, reddish, irregular patch in the lower center is aspen growing on geologically unstable surfaces caused from multiple block slides, multiple slumps, multiple earth-flows and multiple debris flows (Case, 1991). Many such areas exist around Kennaday Peak in the vicinity of the Cedar Pass road (See landslide area map in Appendix on Watershed Health).

Color Infrared Photo #2961-23 August, 1989 T17N R81W

A-4. Irregular-edge block cuts of various sizes, strip cuts, 2-3 step shelterwood cuts.

Medicine Bow River watershed.

Most of the large, irregular edge block cuts in the north half of the photograph were done in the 1970s . The forest matrix is mainly lodgepole pine with stand origin dates from the 1840s to the 1870s. Two large private land holdings are evident. (A) is a mountain subdivision, (B) is a section of State Land. Strip cuts in the lower two thirds of the photograph are in Willow Park (lower right), along the east Fork of the Medicine Bow River (lower center) and in the Medicine Bow River watershed in a kettlehole area called Stillwater Park (lower left center). Strip cuts date from 1950 to 1987. The forest matrix behind the strip cuts dates from the late 1700 to early 1800s, based on remnant uncut areas. Small clearcuts were also placed in leave strips in Willow Park. Strip clearcutting was indiscriminate around kettlehole areas in the Medicine Bow River and East Fork Medicine Bow River watersheds.

Colorado Infrared Photograph #2953-15 August, 1989 T18N R79W and R80W

A-3

N

A-4

A-5. Block cuts, strip cuts, 2-3 step group shelterwood cuts, group selection cuts

French Creek, Mullen Creek, Savage Run, Upper Douglas Creek

The north-face of French Creek Canyon (A -lodgepole pine and spruce fir forest of late 1700s-early 1800s) and Savage Run Wilderness (B - lodgepole pine and spruce-fir forest of late 1600s, 1700s based on limited data) appear as dark patches. The row of block cuts along the ridge of French Creek date from 1971. These high elevation cuts are visible from the Snowy Range Highway. Strip cuts to the west and south date from the 1760s and 1970s, including cuts near the wilderness area. The large clearcut in the headwaters of Douglas Creek (C) was done in 1976. This photograph shows some of the differences betwen the northern part of the Medicine Bow Mountains with steep canyons and the southern portion which is flatter, less dissected and has large meadows.

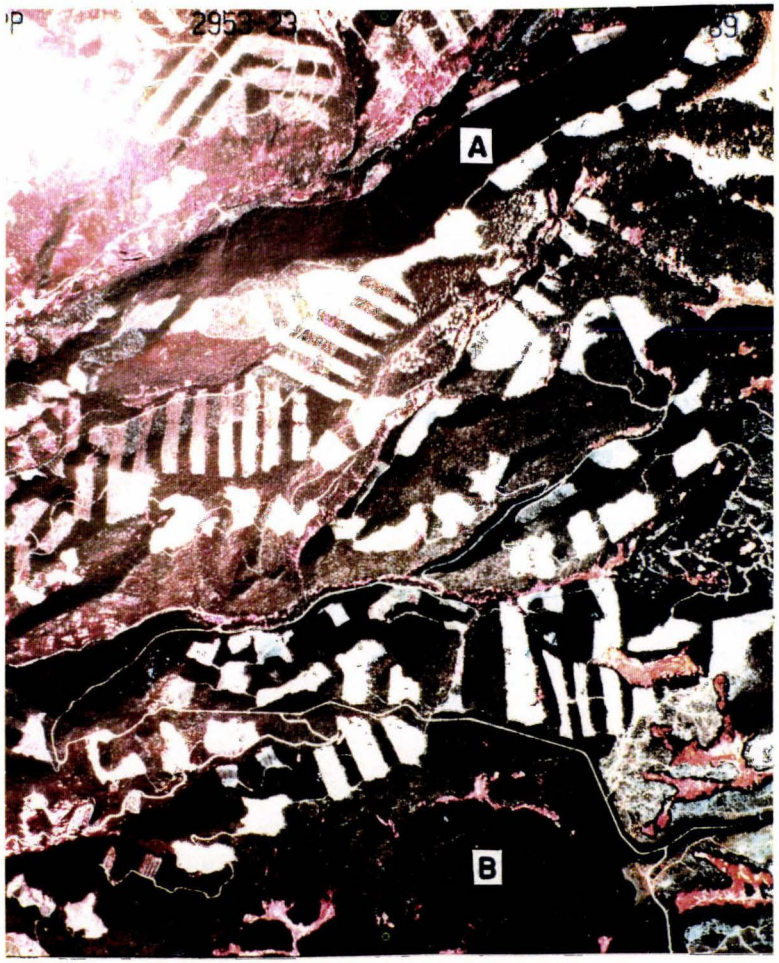
Color Infrared Photo 2953-23 August, 1989 T15N R80W

A-6. Large clearcuts, strip cuts, group selection cuts

Douglas Creek

This photograph includes the lower right corner of photgraph A-4. The large clearcut, surrounding the Douglas Creek headwaters, north of the road was done in 1976. The clearcut south of the road was done in 1974. The forest matrix was spruce-fir dating from the mid-1700s. A narrow fringe of trees was left around meadows containing willows and sedges. The NW-SE road across lower left corner of the photograph is road 511 along the ridge between Savage Run Creek and Douglas Creek. Uncut forest was left along the road for visual purposes. Color Infrared

Photo 2953-23 August, 1989 T15N R79W



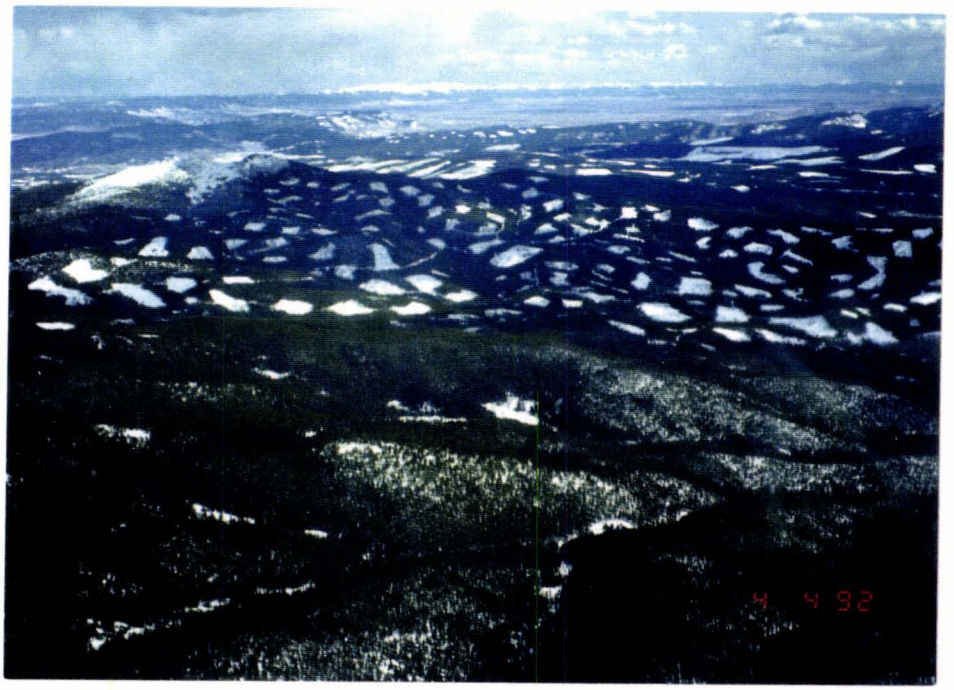
A - 5

N

A - 6

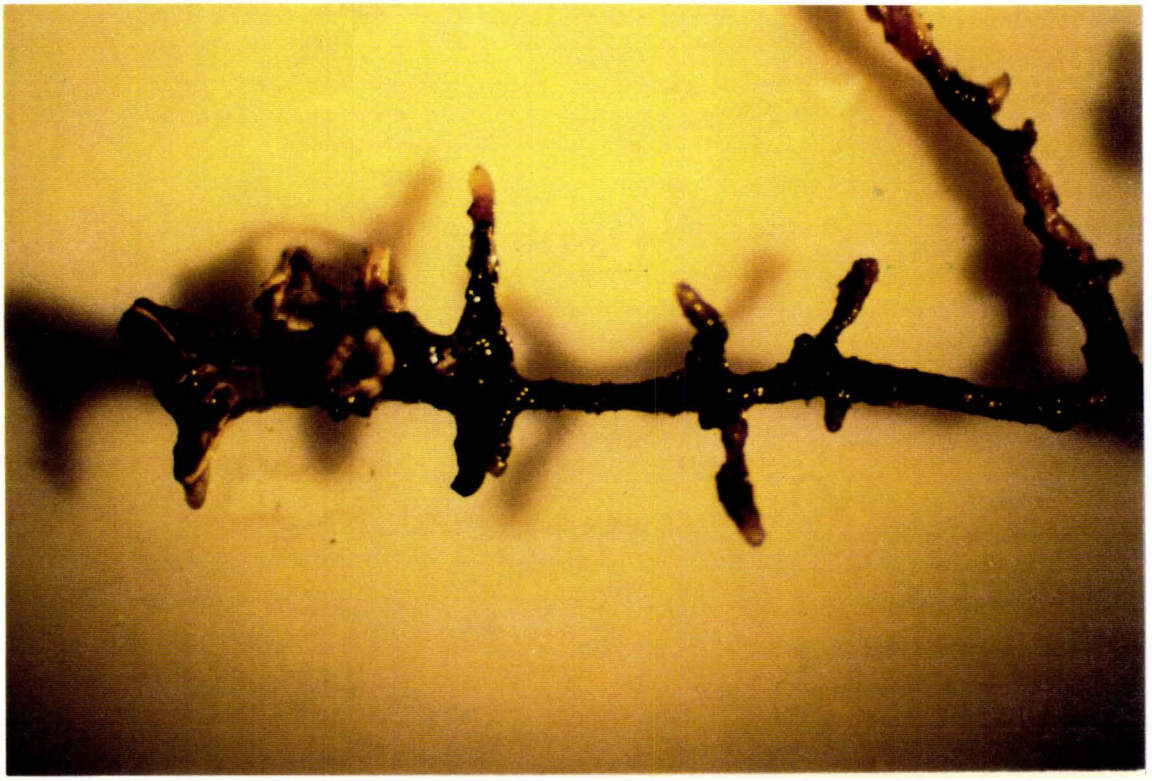
A-7 View across the Rock Creek watershed toward the NE side of Medicine Bow Peak. Sevenmile creek is in the lower center of the photo. Rock Creek Ridge runs across the lower 1/3 of the photograph. Trail Creek and the South Fork of Rock Creek are in the right-center. Prior to 1965 this was a continuous late seral lodgepole pine and spruce-fir old-growth forest, with most stands 200 to 300 years old. Block clearcutting occurred from 1965 to 1976. Photo courtesy of Friends of the Bow. 1989.

A-8 These strip cuts are southwest of Medicine Bow Peak. Large patches of "young" forest have been created within old spruce-fir and lodgepole forest by stripcutting and partial cutting in the leave strips. Photo courtesy of Friends of the Bow. 1989.



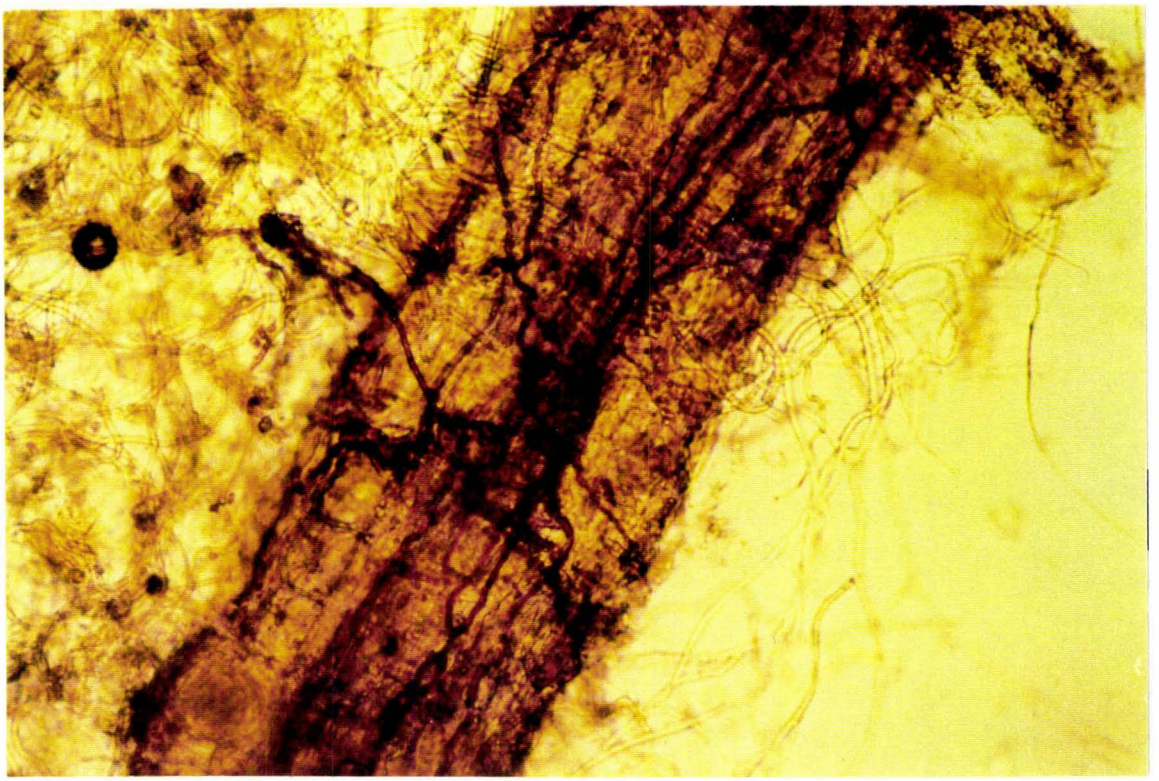
A-9 The Coon Creek Experimental Watershed Project, viewed to the SE toward North Park and the Rawah Mountains. The East Fork of the Encampment River (control area) for the cut area is in the foreground. The Coon Creek Project is an experimental cutting pattern (1989-1991) to measure effects of timber harvest on water yield. About 30% of the watershed was clearcut. Courtesy of Friends of the Bow. April 4, 1992.

A-10 Clearcuts (1981-1990) in the northwestern Sierra Madre Mountains looking eastward to Medicine Bow Peak. This is along the continental divide and the Mowry Creek watershed. Courtesy of Friends of the Bow. April 4, 1992.

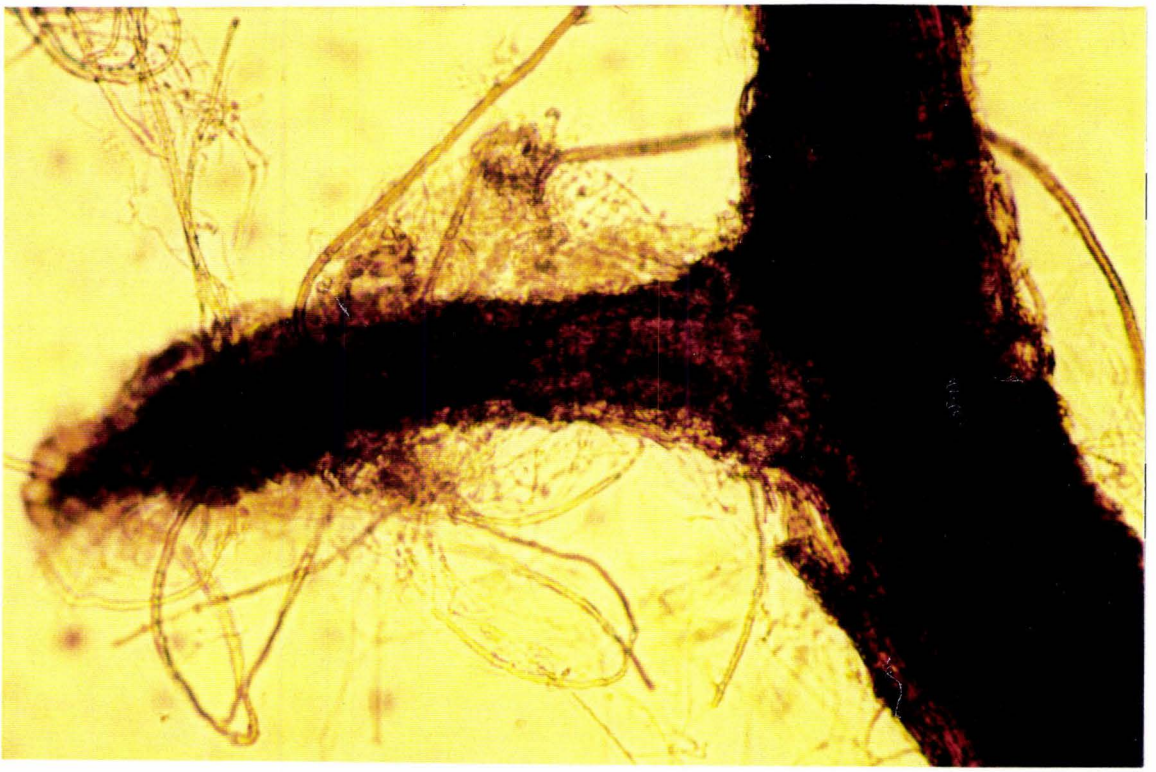


M-1 Ectomycorrhizal tips on conifer root. The fungal associate colonizes root tips and helps trees take in water and nutrients. These are small roots of spruce or fir trees. Courtesy of Dr. Zhipeng Zhao.

M-2 This is a magnified view of well-developed conifer ectomycorrhizae obtained during 1993. Courtesy of Dr. Zhipeng Zhao.



M-3 Mutualistic ectomycorrhizae form a hyphal net around a *Vaccinium* root. The fine strands of fungus envelope the root and assist in nutrient uptake. The root also supplies the fungus with nutrients. Magnified view. Courtesy of Dr. Zhipeng Zhao.



M-4 Ectomycorrhizal fungal mass around *Vaccinium* root. Magnified view. Courtesy of Dr. Zhipeng Zhao.

CHAPTER 6

TERRESTRIAL ECOSYSTEMS

INTRODUCTION

An overview of major terrestrial landscapes and communities is presented in this chapter. Ecosystem diversity at the coarse-filter scale, including landscape patterns, forest type and age, and continuity through time is discussed. Ecosystem processes and functions such as disturbance, succession, and flows of energy and material are reviewed. Wherever possible, data are from studies on the Medicine Bow National Forest or Fraser Experimental Forest. Studies pertaining directly to ecosystems on the MBNF are in Appendix 1.

LANDSCAPE ORGANIZATION

BIOLOGICAL DIVERSITY UNITS AND AREAS

A watershed-based approach to analysis of biological diversity characteristics was used for this report. Watersheds on the MBNF have been delineated for fifth through eighth level using the USGS watershed classification. Fifth level watersheds are the largest units pertinent to the scale of the MBNF, while eighth level watersheds are smallest (stream reaches). Watershed levels nest spatially and hierarchically. Details of watershed organization and characteristics (numbers, names, acreages) are in Appendix 2.

Watersheds are called Biological Diversity Units (BDU's) in this report. BDU's are fifth, sixth or seventh level watersheds ranging in size from about 5000-30,000 acres. BDU's are grouped into larger units called Biological Diversity Areas (BDA's) (Figure 6.1). BDA's and BDU's are fundamental units for both maps and tables. Most maps in this report have a BDA/BDU overlay. Watersheds and groups of watersheds are used as subdivisions of the four mountain ranges to provide a suite of different spatial scales for description of biological diversity.

All acreages are calculated with Arc-Info Geographic Information Systems (GIS) using data from the MBNF Resources Information Database (RIS). Acreages calculated with GIS may vary in the aggregate up to approximately plus or minus two percent from acreages recorded in attribute files of the RIS database or which were reported in the 1985 Forest Plan from planimetric estimates.

LANDSCAPE DIVERSITY

The elevational range of the Medicine Bow National Forest is nearly 1.3 vertical miles, from 12,013 feet on Medicine Bow Peak to about 5200 feet where Horseshoe Creek crosses the National Forest Boundary in the Laramie Mountains at the edge of the Great Plains. Major cover types of the MBNF are presented in Figure 6.2a-d. These maps and the following figures are used for reference throughout the discussion of ecosystems. Major upland cover types for each mountain range, as a percent of upland ecosystems shown in the maps, are in Figure 6.3. Acreage of upland cover types, by watershed or groups of watersheds within the mountain ranges, is in Appendix 11.

COMMUNITY MOSAIC DIAGRAMS

Community mosaic diagrams show vegetation diversity at the broad scale in relationship to elevation gradients and moisture or topographic gradients. Community mosaic diagrams for four areas in the Southern and Central Rocky Mountains were prepared by Peet (1978a, 1978b, and 1981). These were based on field work in the Spanish Peaks (Colorado), the Sangre de Cristo Mountains (Colorado), Rocky Mountain National Park (Colorado), and the Medicine Bow Mountains (Wyoming). The community mosaic diagram for the Medicine Bow Mountains is Figure 6.4.

Some regional differences between the MBNF and forests in Colorado can be noted by comparing the community mosaic diagram for the Medicine Bow Mountains with one for Rocky Mountain National Park (Peet 1978a, 1981) (not shown).

- The Medicine Bow Mountains lack extensive Douglas fir forests found in the Park
- Subalpine fir occupies a larger part of both the moisture and elevation gradient on the MBNF than in the Park
- Limber pine occupies a wider elevation range on the MBNF than in the Park
- The MBNF has a limber pine-aspen zone at 7000-8500 feet
- Upper timberline is lower on the MBNF, with more krummholz

A hypothetical community mosaic diagram for the Sierra Madre Mountains would be similar to Figure 6.4, but with the addition of Gambel oak shrubland below the limber pine-aspen zone at about 5500-6500 feet. A hypothetical community mosaic diagram for the Laramie Mountains and Sherman Mountains would be different than Figure 6.4 because there are no alpine or timberline zones, lodgepole pine would occupy a narrower elevation zone, and ponderosa pine would occur all the way across the moisture gradient at 6500-8000 feet.

A community mosaic diagram showing the relationship of major vegetation patterns to topographic positions and moisture gradients in the Savage Run Wilderness Area of the MBNF is in Figure 6.5 (Romme and Knight 1981).

VEGETATION CLASSIFICATION

No region-wide vegetation classification system exists in 1995. Vegetation is classified in the MBNF RIS data base by overstory plant cover type (example: spruce-fir, lodgepole pine, grass, forb). For this report, available information on plant associations and habitat types is synthesized into a working community type vegetation classification for the MBNF (Appendix 6). Acreage estimates for specific community types (overstory/understory) are not available. Acreages for overstory plant cover type categories (RIS data base) were used to prepare the maps and tables. The most specific classification level of vegetation available was used to describe a given aspect of biological diversity.

MAJOR TERRESTRIAL ECOSYSTEMS

ALPINE ECOSYSTEMS

The Medicine Bow Peak alpine area is only a few square miles in size, but is a valuable component of landscape diversity on the Medicine Bow National Forest. The Sierra Madre Mountains are not high enough to have much alpine area. Bridger Peak, at 11,004, feet is about 1000 feet lower than Medicine Bow Peak and is barely at timberline. Laramie Peak (10,200 feet) is well below timberline. Alpine zones of Rocky Mountain National Park and Niwot Ridge west of Boulder, Colorado are comparable, but larger areas. Many aspects of alpine ecology near in the Medicine Bow Mountains have been well studied since the 1920s.

Fellfields, alpine meadows and forblands, fens, and willow carrs are the main kinds of alpine vegetation types. Talus, moraines, and other glacial landscape features furnish substrates that create mosaics at many scales. The Medicine Bow Peak alpine area has some special landscape features such as patterned ground, consisting of stone polygons on unglaciated areas (nunataks) (Mears 1953; Mears 1962), and frost boils on wet ground (Ray 1940; Billings and Mooney 1959). Frost boils form when wind erosion causes degradation of peat which has been pushed up by frost action. Rocks are thrust through from below, causing sorting into polygons. Subsequent drowning of sorted polygons by a rising water table allows sedges to invade the rocky intervals. Drier peat borders are occupied by dwarf willows, forbs, and sedges, adding to the diversity of alpine species and communities. Many saxicolous (rock) lichens are found in the alpine tundra environment. Alpine and subalpine forblands interdigitate in the complex

timberline area around the high peaks of the Snowy Range. Interaction of vegetation and drifting snow strongly controls landscape patterns in the alpine (Billings and Bliss 1959; Billings 1969).

The substrate beneath alpine areas is mostly massive Precambrian metaquartzite, which forms the spectacular glaciated face of Medicine Bow Peak. Complexes of schists, gneiss, and various metasedimentary rocks flank the metaquartzite of Medicine Bow Peak. These rock types weather very slowly and soil formation is in early stages in many alpine areas.

Soils in the alpine zone have been forming since deglaciation (about 18,000 years). Alpine areas underwent repeated glaciations during the Pleistocene, which removed soils formed during interglacial stades (Bliss 1956). Paleosols formed during the early and middle Pleistocene can be found under forests in lower elevation areas. Soil development in different stages since deglaciation, from bare soil and rudimentary lichen crusts to a developed soil profile supporting meadows and forests (below timberline), are evident in the Medicine Bow Peak area. Subalpine and tundra meadow vegetation forms the interstices between ribbons or among clumps of krummholz (Photos E-1, E-3, E-5). Often ribbon forest and krummholz grow on rocky moraines, while meadows form on till or wetter concave areas of the landscape. Wet and dry areas are often sharply defined.

Plant development in microenvironments of arctic and alpine tundra was evaluated by Bliss (1965), comparing the Medicine Bow Mountains with the Brooks Range in Alaska. He concluded that alpine tundra of the Snowy Range of Wyoming is a more severe environment for plant development than arctic tundra of Northern Alaska. High winds, low humidity, cold soil temperatures, high ultraviolet radiation, low soil moisture, and great daily temperature fluctuations make the Snowy Range more severe than the sea-level arctic environment.

Most vascular plants are characteristic of alpine areas throughout the Rocky Mountains (Appendices 4 and 6).

Upper Timberline

Timberline vegetation includes krummholz (German for "crooked wood") banner trees, and ribbon forest. These forms are easily observed from the road on Libby Flats which is subjected to prevailing strong west and northwest winds (Photos E-3, E-5).

This harsh timberline environment is severely limiting for woody plant development. Engelmann spruce and subalpine fir grow horizontally, rooting at branch nodes. Krummholz controls and is controlled by snow drifting. Occasional vertical stems often have all the branches on the windward side worn off (banner

trees Photo E-109). Wind driven snow and ice removes the wax layer of needles in years of low snowfall, causing mortality of vertical stems and outside branches of krummholz (Hadley 1986; Hadley and Smith 1986, 1989). Krummholz and ribbon forest reproduction, survival, and growth may be a biological indicator of climate change.

Ribbon forest occurs only on locally and regionally unusual sites that have great winter snow accumulations caused by heavy direct snowfall, entrapment of snow blowing from adjacent treeless areas, or both (Buckner 1977). The flat, high elevation erosional surfaces around Medicine Bow Peak are well-suited to ribbon forest formation (Photo A-2). Limited areas of ribbon forests on steeper slopes occur on Bridger Peak in the Sierra Madre Mountains.

Initial studies of MBNF ribbon forests were done by Billings (1969) to examine interactive effects of fire and snowdrifts on timberline patterns. Further study of MBNF ribbon forest, krummholz establisment, and age was completed in 1993 (Earle 1993). Ribbon forests establish by new seedlings and grow by infilling and slow expansion of seedling trees. They are maintained in relation to drifting snow behavior. Engelmann spruce and subalpine fir differ with regard to seedling establishment and survival. Krummholz also establishes by seedlings, but expands mainly by cloning.

Long periods of sporadic establishment occurred for both spruce and fir in ribbon forest from the mid-1300s to about 1750 (Earle 1993). Increased rates of ribbon forest establishment occurred after 1750 and peaked in the 1870s and 1880s. A precipitous decline in establishment began after about 1910, with very little recruitment since 1930. Since 1976 no new trees established in the areas studied and no new leaders have been released in krummholz clumps. Median death age within ribbons for subalpine fir was 180 years, for Engelmann spruce it was 220 years. Maximum tree ages for Engelmann spruce were over 500 years (Earle 1993). Ribbon forests do not usually burn, but individual trees may be ignited by lightning and killed. Many ribbon forest trees show lightning strike scars.

The optimum climate for ribbon forest establishment may be different than the optimum climate for growth. Historical periods of warm summers appear to be favorable for seedling establishment, while snowy winters appear to favor survival and growth of both krummholz and ribbon forest. The overall cold climate of this century (compared to the 1800s), at least up to the past few years, may have discouraged additional seedling recruitment in ribbon forest.

Studies of displacement ecology of trees near upper timberline in the Medicine Bow Mountains near the Glacier Lakes Experimental Ecosystem Sites (GLEES) concluded that tree establishment in subalpine meadows at this site (a protected site, not a ribbon forest or krummholz area) was related to slight cooling periods

in an otherwise warming century (Moir and Lee 1990; Moir and Huckaby 1994). These studies perhaps evaluate a different scale of climate trends than Earle (1993).

Sequences of favorable climatic years may increase chances for tree establishment at microsites, but successful establishment depends on interactions of other events such as grazing, soil disturbance which reduces competition, fires, heavy seed crops, and favorable local growing conditions. It is possible that timberline trees in different environments may respond to different environmental and biotic factors for establishment and survival in very complicated ways.

An interesting point regarding tree age on the MBNF is that the oldest known trees occur near upper and lower timberline in the Medicine Bow Mountians. Engelmann spruce in excess of 700 years old were discovered near Brooklyn Lake (Moir personal communication). Another Engelmann spruce dates from the year 1421 which would make it at least 573 years old (Earle 1993). This is a minimum estimate since dendrochronology methods are conservative with regard to tree age. The oldest tree known from lower timberline is a 30 inch DBH Douglas fir growing in a rock outcrop on the west side of Sheep Mountain. Its origin date is 1412, which makes it at least 582 years old. A limber pine in the same area was at least 514 years old (Earle personal communication).

Non-forested environments in the timberline area include upland and riparian forblands, grasslands, and willow shrublands. Prior to introduction of domestic stock about 1890, herbivory in alpine and subalpine areas was mostly from small native birds and mammals such as pikas, marmots, hares, and ptarmigan.

All high elevation areas in the Medicine Bow Mountains have been grazed by sheep for about a century. It is not known how much 100 years of sheep grazing has altered high altitude grasslands and forblands. Several Forest Service reports prior to 1940 cited poor condition of high elevation rangelands, especially in the Sierra Madre Mountains. Sheep grazing and bedding areas have been important uses of the alpine and subalpine meadow systems associated with ribbon forest and krummholz.

Use by domestic stock creates patches of disturbance from herbivory, trampling and nutrient input from feces and urine. Dry meadows immediately adjacent to ribbon forest often consist of alpine avens communities or other forbs not palatable to sheep. Populations of some plant species, adapted to disturbed conditions, or thriving where there is little competition from other plants, may increase in areas affected by sheep grazing. Large populations of black headed daisy, an alpine species of concern to the Nature Conservancy, were seen in dry forblands associated with past sheep grazing in 1994 in the potential Ribbon Forest RNA (von Ahlefeldt personal observation).

Studies on high elevation grasslands are briefly reviewed below. An early study in a series of investigations on impacts of livestock grazing on alpine ecosystems in the western United States characterized vegetation, soils and their interrelationships at timberline in the Medicine Bow Mountains (Smith, 1956). In 1962, W.M. Johnson published a University of Wyoming Agricultural Experiment Station Bulletin on vegetation of high-altitude sheep ranges in Wyoming, which included the MBNF. Thilenius (1970) assembled a review of 27 ecological studies on the alpine tundra and subalpine grasslands of the Medicine Bow Mountains between 1941 and 1970. These included studies on alpine plant physiology, range sampling techniques, biomass production, plant community studies, and the effect of using herbicides to destroy forbs and encourage grasses on high altitude ranges. In 1975, the Rocky Mountain Forest and Range Experiment Station (RMFRES) published a status report on Alpine Range Management in the Western United States which included the Medicine Bow Peak area (Thilenius, 1975).

Most alpine and subalpine meadows on the MBNF in both the Sierra Madre and Medicine Bow Mountains are currently in active sheep and cattle allotments. An exception is the 1994 withdrawal from sheep grazing of the portion of the Libby Flats Allotment north of the Snowy Range Highway. This withdrawal will provide a grazing-free area which may help in the assessment of what changes in vegetation may occur in high-altitude ranges in the absence of grazing, although it may take a long time to see differences.

The Glacier Lakes Experimental Ecosystem Experiments Site (GLEES) is located in a cirque basin surrounding West Glacier Lake northeast of Brooklyn Lake (Photo E-2). It is located in a subalpine environment, protected from fierce north and west winds by quartzite cliffs on the steep cirque face of Browns Peak. The GLEES site was established in the late 1980s to conduct research in ecosystems typical of high altitude wilderness areas in the West. Many studies have been done including intensive surveys of soil, vegetation, lichens, measurements of atmospheric deposition into snow and water coming from the lake, and lake outflow rates which respond to winter snowpack and daily temperatures. GLEES is a member of the National Atmospheric Deposition Program and the National Dry Deposition Network and is a Soil Conservation Snowcore Site. Cooperative research is conducted with many agencies (Fox et al. 1987). A recent review of research activities at GLEES is available in Musselman (1994). Most of the research conducted at GLEES is very broad scale and not of immediate application to local management.

CONIFEROUS FORESTS AND WOODLANDS

Coniferous forests cover most of the terrestrial ecosystem surface on the MBNF. Coniferous forests are also important riparian ecosystem components at higher

elevations (approximately 9500 feet to 11,000 feet) in the northern Medicine Bow Mountains and the Sierra Madre Mountains. Below about 9500 feet, riparian ecosystems are often dominated by willows or wet meadows. A discussion of mountain forest ecosystems applicable to the Medicine Bow Mountains is in *Mountains and Plains: The Ecology of Wyoming Landscapes* (Knight 1994).

The most common coniferous tree species on the MBNF are Engelmann spruce, subalpine fir, Douglas fir, lodgepole pine, ponderosa pine, and limber pine. Scattered stands of Rocky Mountain juniper are found mainly in the Platte River Canyon or near the Forest boundary in the Medicine Bow Mountains. The percent cover of major tree species for each mountain range is in Figure 6.7. Acreage tables for cover types by watersheds are in Appendix 11.

Present-day ranges of these conifer trees are in Figure 6.6 a-g. Note that the MBNF is near the southern end of the range of lodgepole pine which extends from the Colorado-New Mexico border nearly to the Alaskan-Canadian border in northern Alberta. The most extensive lodgepole pine forests are in the northern Rockies in Canada. Engelmann spruce and subalpine fir occur predominantly in the same range as lodgepole pine, but are found considerably further south, well into Arizona and New Mexico. Spruce is the dominant member of spruce-fir forests to the south. On the MBNF subalpine fir is often more common except in very old, high elevation spruce-dominated forests.

The MBNF is rather centrally located in the ranges of ponderosa pine and Douglas fir, which extend from Mexico to southwestern Canada. Limber pine has a much more restricted range, occurring mainly in the central and southern Rocky Mountains. Rocky Mountain juniper occurs on both sides of the Continental Divide, with scattered populations extending into the Great Plains and Great Basin on escarpments.

Biotic and abiotic interactions of tree species vary over their ranges. These may include disturbance processes, forest insect and disease occurrence, vegetation behavior over geologic time in relation to climate and relationships with animal associates. For example, the tufted eared (Abert's) squirrel is associated with ponderosa pine over much of its range in New Mexico, Arizona, and Colorado as it dispersed northward from Mexico during post-Pleistocene climate warming (Davis and Brown 1989). The present northern range limit of Abert's squirrel is south of Interstate-80 in the Sherman Mountains. It has also been observed an Boulder Ridge, which extends into the southern Laramie Basin from Colorado, west of Tie Siding, WY (Rothwell 1995). The northern extent of ponderosa pine dwarf mistletoe is a few miles to the south on the Arapaho-Roosevelt NF in northern Colorado. Although forests of ponderosa pine exist on the Laramie Peak area, and to the north past the Canadian border, neither Abert's Squirrel or dwarf mistletoe associate with them. Evidently neither the squirrel nor the dwarf

mistletoe (which is dispersed by birds) have been able to cross the climate or physical barrier of the cold, arid Sherman Mountains which do not support continuous ponderosa pine forest. It has been suggested that the squirrel has not yet dispersed to these areas since the end of the last glacial time (Davis and Brown 1989). Thus, ponderosa pine ecosystems on the Medicine Bow National Forest in Wyoming lack both dwarf mistletoe and Abert's squirrel, two important components of biological diversity common in ponderosa pine forests in other nearby National Forests to the south.

Engelmann Spruce and Subalpine Fir Forests

Engelmann spruce and subalpine fir are both shade-tolerant species. They commonly occur as successional species in understories of mature lodgepole pine forests below 10,000 feet in the Sierra Madre and Medicine Bow Mountains. They also form late-seral forests above about 8000 feet. At high elevations, spruce and fir establish directly without an earlier lodgepole pine forest seral stage. Spruce fir forests occur up to timberline (11,000 feet), above the elevational range limit of lodgepole pine (Figures 6.8a,b).

In the Sierra Madre Mountains most spruce-fir forests are aggregated at the top of watersheds near the Continental Divide, but in the Medicine Bow Mountains spruce-fir forests occur as a major percentage of cover throughout many of the watersheds in the northern portion of the Snowy Range. In the southern Snowy Range spruce-fir forest is often found in low topographic positions which have not burned for several hundred years.

The matrix of older spruce-fir forests along upper north-facing shoulders of French Creek and Brush Creek canyons contains patches of (~150 year old) lodgepole pine which likely originated after fires in the 1800s (von Ahlefeldt personal observation). Spruce-fir distribution in the Sierra Madre Mountains also had been affected by fires since about 1850.

The very patchy occurrence of spruce-fir forest in the southern Medicine Bow Mountains and Sierra Madre is due to a combination of climatic factors, disturbance from fire or blowdown, and timber harvest. Spruce-fir forest would develop over most of the Sierra Madre and southern Medicine Bow Mountains (except for Sheep Mountain and the Platte River Canyon area) in the absence of stand-destroying disturbances, based on the presence of remnants which are 300+ years old (RIS data base).

In the Sherman Mountains and Laramie Mountains spruce-fir forest distribution is limited to north-facing slopes above about 8500 feet (Figures 6.8 c,d). Old forests containing predominantly Engelmann spruce occur at high elevations of the Medicine Bow Mountains. White spruce (*Picea glauca*) has been reported

near the top of Laramie Peak (Ron Hartman, personal communication). This is a disjunct occurrence and it appears that these trees may hybridize with Engelmann spruce at about 10,000 feet. Subalpine fir is more common than Engelmann spruce at higher elevations in the Sherman Mountains and Laramie Mountains. Diversity by percent cover of cover classes by mountain range is in Figure 6.7. Appendix 12 has acreages at the watershed level for all mountain ranges.

Diseases and Insect Infestations

Serious insect or fungal attacks are not of historic occurrence in spruce or spruce-fir forests on the MBNF, although spruce beetles are endemic and small outbreaks have occured on Green Mountain south of Encampment, on Upper French Creek in the 1970s, and in logging residues (Schmid personal communication). Spruce beetle has not been documented as a serious pest here, although it causes major tree mortality in high-elevation spruce-fir forests of Colorado and New Mexico (Schmid and Hinds 1974; Veblen et al. 1991). The potential for serious outbreaks is unknown.

Broom rusts are found on spruce and fir. *Chrysomyxa* has kinnikinnik as an alternate host and *Melamsporella* has chickweed as an alternate host. These rusts occur at low levels (Geils personal communication).

Lodgepole Pine Forests

Lodgepole pine is the predominant coniferous species over most of the Sierra Madre and Medicine Bow Mountains below about 9800 feet. Between about 9300 and 10,000 feet it often occurs as late-seral lodgepole pine forest with varying proportions of Engelmann spruce or subalpine fir. In older stands, lodgepole pine may be represented by a few, old individuals. It is a common species on Pole Mountain in the Sherman Mountains and at the north end of the Laramie Mountains. The distribution of lodgepole pine in the Sierra Madre and Medicine Bow Mountains is shown in Figure 6.9a,b. Occurrence of lodgepole pine in the Sherman Mountains and Laramie Mountains is shown in Figure 6.2 c,d.

Lodgepole pine recolonized deglaciated and other barren areas in the last 12,000 years (Wheeler and Critchfield 1984). Its ability to colonize bare, deglaciated sites is also the key trait that makes it a pioneering species in severely disturbed areas and amenable to timber management by clearcutting. Lodgepole pine is a disturbance-adapted species which also grows in canopy gaps created by individual or small groups of dead trees. It behaves, in a sense, as a "woody weed."

Critchfield (1985) recognized three centers for lodgepole pine recolonization after the Pleistocene: 1) Pacific coastal area, 2) Yukon, and 3) south of, or lower than, the ice in the Rocky Mountains. These were "nodes" for recolonization of lodgepole pine in the last 12 millenia (See dashed lines separating types in Figure 6.4c). Differences in cone serotiny, number of needles per fascicle, time of terminal bud formation, and other structural-physiological differences suggest that there are genetic differences in lodgepole pine which predate glaciations and continue to impart diversity to the species over its range (Wheeler and Critchfield 1984).

Genetic diversity of cone serotiny is variable in local lodgepole pine populations. Fire regeneration tends to favor serotinous cones. Timber harvest may favor serotinous cones depending on a number of factors. These factors include post-harvest treatment and the percentage of serotinous cones which open. Thus the ability of an area to regenerate after fire may be influenced by local management because of the characteristics of post-harvest stands with regard to populations of serotinous cones (Lotan, 1974; Tinker and Romme et al. 1994). Status of populations of serotinous vs non-serotinous cones in regenerated stands is a possible monitoring item.

Physiological adaptations enable lodgepole pine to grow well in cold environments such as the MBNF. Lodgepole pine seedlings are able to tolerate low night temperatures better than ponderosa pine seedlings (Berntsen 1967). Lodgepole pine seedlings approximately one month old or younger survived night time temperatures below 23 degrees Fahrenheit more often than ponderosa pine seedlings in growth chamber experiments (Cochran and Berntsen 1973). Seedling age interacted with temperature tolerance. The pattern of occurrrence of lodgepole pine mostly above 7600 feet on Laramie Peak may be due partly to night time temperature tolerance which limits ponderosa pine to below 7600 feet.

Prevalence of lodgepole pine over much of the Sierra Madre and southern Medicine Bow Mountains is a function of both climatic limitations and disturbance. Widespread fires between about 1870 and 1910, selective removal of trees by tie-hacking (1879 - circa 1950), clearcutting (1950 - present), and fire suppression appear to be the major factors responsible for the pattern and structure of most lodgepole pine stands below 9800 feet in these areas. The presence of extensive areas of lodgepole pine less than 150 years old in the Sierra Madre and southern Snowy Range is likely due in large part to human-caused forces which have kept these forests in an extended early to mid-seral condition (Appendix 12).

- Comandra blister rust

Comandra blister rust (*Cronartium comandrae*) is a common forest disease of lodgepole pine, especially in the central part of the Medicine Bow Mountains. A forb, pale comandra (*Comandra umbellata*) is the alternate host for the fungus (Geils and Jacobi 1987; Jacobi et al. 1993). Comandra blister rust kills lodgepole pine seedlings and causes deformation (dead branches and spike tops) as well as slowed growth in older trees. Disease incidence was 27-35 percent infection on the Laramie Ranger District in 1990 (Lundquist and Lister 1991).

Comandra blister rust infection occurs during short time periods in the summer when spore production by the fungus coincides with damp weather brought by easterly winds, which distribute the spores over lodgepole pine forests west of the Laramie Plains. Degree and likelihood of infection are related to distance and topography (Jacobi et al. 1993). A rating system for potential losses has been developed for the Laramie Ranger District by the Rocky Mountain Forest and Range Experiment Station (Geils and Jacobi 1989).

- Dwarf mistletoe

Dwarf mistletoe, *Arceuthobium americanum*, is especially common at lower elevation; warm, dry sites; and drier habitat types (Hawksworth 1958). Both comandra blister rust and dwarf mistletoe are parasites that cause deformation (spike tops, witches brooms, dead branches) slowed growth, and tree death (Geils 1984; Hawksworth and Weins 1972). For wood production this is undesirable, but from a biological diversity viewpoint, infected trees add variety to stand structure for birds and other small animals, and dwarf mistletoe seeds are a food source for many animals. Dead trees are important for snag-dependent species. Plant pathogens change conditions for competetition, establishment and mortality, they affect successional processes, and they change the availabilty of material for decomposition (Dinoor and Eshed 1984). Dwarf mistletoe also causes structural and physiological changes in trees which contribute to biological diversity not found in stands free of dwarf mistletoe (Gill and Hawksworth 1964, Hawksworth 1975; Alexander and Hawksworth 1975; Tinnen et al. 1982; Tinnen 1984).

A discussion of biotic associates of dwarf mistletoe is in the forthcoming book *Dwarf mistletoes: biology, pathology and systematics* (Hawksworth and Weins 1995):

> With increased awareness of the complex interactions among dwarf mistletoes and other biotic associates and heightened interest in biodiversity and forest health, mistletoe control assumes a new

dimension. Dwarf mistletoes are no longer viewed as "pests" requiring eradication but as biotic agents of disturbance that can profoundly affect forest communities.

Lodgepole pine in the MBNF is variably infected with dwarf mistletoe (Figure 6.10, RIS database). Scattered light dwarf mistletoe infection (Hawksworth ratings .1 - 1.9) is found in lodgepole pine of the Laramie Mountains. Surveys are not complete, but dwarf mistletoe infection does not appear to be a serious tree health problem at this time in the Laramie Mountains. In the Sherman Mountains dwarf mistletoe infection is mostly light, but widespread, especially in the Pole Mountain area and the northwestern part of the unit.

In the Medicine Bow and Sierra Madre Mountains, light dwarf mistletoe infection occurs ubiquitously in lodgepole pine stands and in the lodgepole pine component of late seral mixed conifer stands. Moderate dwarf mistletoe infection (Hawksworth rating 2.0 - 3.9) is primarily in the northern and southeastern Sierra Madre, lower Brush Creek drainage, southern Medicine Bow Mountains, and in scattered locations along the northeastern border. Heavy dwarf mistletoe infestations (Hawksworth ratings 5-6) follow moderate infection patterns. Areas free of dwarf mistletoe occur throughout both mountain ranges, in various-sized patches (Figure 6.10). Some dwarf mistletoe-free patches are associated with past fires (for example the large patch east of Blackhall Mountain), others are in old forests, and some are in areas clearcut since 1950. "Sanitation" of forest stands (removal of dwarf mistletoe) is done by clearcutting.

Acreages of heavy infection vs no dwarf mistletoe for watersheds are in Table 6.1. These data show that while heavy infection with mistletoe does occur, there are also many acres of uninfected forests, especially in the Sierra Madre and Northern Medicine Bow Mountains. The map in Figure 6.10 also includes no-data areas for pine sites and areas with light and medium infection, which are more widespread.

Mason (1915) observed that serious dwarf mistletoe damage was in scattered, localized areas throughout the Rocky Mountains, but his observations were primarily in virgin stands. Surveys for dwarf mistletoe in the mid-1950s on the Medicine Bow National Forest indicated that areas which were partial cut by tiehacking and selective cutting (1860s - 1950) were 70 percent infected compared to 51 percent in virgin stands and 27 percent in regenerated burns (Hawksworth, 1958). Infection levels were similar for the Arapaho-Roosevelt National Forest, but lower for the Bighorn National Forest, although the pattern was the same. A 1977 dwarf mistletoe survey on the Medicine Bow National Forest (Johnson et al. 1978) reported an infestation rate of 60 percent but did not specify spatial distribution, amount of infection in different areas, or differences in stand types.

Table 6.1. **Dwarf mistletoe status of watersheds. Information source - RIS database 3/95. See Figure 6.9. Percent is based on acres with data (absent, light, medium or heavy infection).**

BDU#	Name	acres	% infected
	HEAVY INFECTION (Hawksworth rating 4.0 or higher)		
Sierra Madre Mountains			
22	E. Fork Encampment River	2132	19%
24	Middle Fork Big Creek	2673	17%
14	North Spring Creek	1642	14%
13	Jack Creek	1288	11%
20	Encampment River Canyon	1039	10%
1	Savery Creek	864	8%
23	Beaver Creek	723	7%
17	N. Fk. Encampment River	297	5%
19	Hog Park Creek	433	5%
18	S. Fork Miner Creek	386	4%
3	Big Sandstone Creek	646	3%
26	South Fork Big Creek	168	3%
25	Bear Creek	51	1%
2	Dirtyman Creek	39	-
15	South Spring Creek	78	-
4	Little Sandstone Creek	44	-
21	Billie Creek	8	-
	DWARF MISTLETOE ABSENT		
		acres	**% not infected**
8	Cottonwood Creek	980	81%
10	North Fork Little Snake	15083	80%
7	Lower Battle Creek	3409	78%
5	Big Gulch	1332	74%
16	Cow Creek	5659	66%
25	Bear Creek	2675	58%
4	Little Sandstone Creek	3968	55%
17	N.Fork Encampment River	2792	54%
12	W. Fork Battle Creek	3779	53%
9	Roaring Fork Little Snake	2908	51%
23	Beaver Creek	4404	45%
3	Big Sandstone Creek	8058	39%
18	S. Fork Miner Creek	3086	36%
11	Upper Battle Creek	2588	33%
2	Dirtyman Creek	2031	30%
24	Middle Fork Big Creek	4304	28%
13	Jack Creek	2621	24%
14	North Spring Creek	2839	24%
22	Billie Creek	1119	22%
19	Hog Park Creek	1544	21%
22	E.Fork Encampment River	2200	20%
1	Savery Creek	1963	19%
15	South Spring Creek	1345	17%
20	Encampment River Canyon	1409	14%

Table 6.1 continued

HEAVY INFECTION (Harksworth rating 4.0 or higher)

BDU	Name	acres	% infected
SNOWY RANGE NORTH			
56	South Fork	2418	29%
36	North Cottonwood Creek	1360	25%
35	Lower Brush Creek	1410	17%
32	Lower North Brush Creek	1472	16%
59	Mill Creek	767	12%
66	East Medicine Bow River	902	12%
62	South Rock Creek	1625	11%
60	Fourmile Creek	1144	10%
57	Middle Fork	1607	9%
58	North Fork	1314	6%
31	South Cedar Creek	327	5%
37	Middle French Creek	530	5%
61	North Rock Creek	935	4%
39	Lower South French Creek	267	4%
30	Pass Creek	472	3%
38	Upper South French Creek	313	3%
34	South Brush Creek	338	3%
63	West Medicine Bow River	52	-
65	Lower Medicine Bow River	28	-
67	Wagonhound Creek	19	-
33	Upper North Brush Creek	65	-
SNOWY RANGE SOUTH			
47	Muddy Creek	2503	41%
49	Devils Gate Creek	2021	31%
43	Pelton Creek	5127	26%
46	Lake Creek	2355	24%
48	Middle Douglas Creek	2275	22%
45	Mowberg Creek	1318	21%
42	Platte River	2978	19%
44	Lower Douglas Creek	1689	15%
51	Boswell Creek	880	10%
53	Lake Owen Creek	1494	10%
50	Upper Douglas Creek	788	7%
52	Bear Creek	602	6%
41	Cottonwood Creek	409	5%
40	Mullen Creek	173	1%

Table 6.1 concluded

DWARF MISTLETOE ABSENT

BDU	Name	acres	% not infected
SNOWY RANGE NORTH			
64	Upper Medicine Bow River	2097	80%
38	Upper South French Creek	6493	65%
33	Upper North Brush Creek	6514	64%
58	North Fork	13191	60%
34	South Brush Creek	4950	54%
29	Rankin Creek	3272	52%
65	Lower Medicine Bow River	3878	51%
62	South Rock Creek	6962	48%
63	West Medicine Bow River	3309	46%
27	South Fork Lake Creek	1788	46%
30	Pass Creek	5565	42%
37	Middle French Creek	4418	42%
59	Mill Creek	2375	38%
32	Lower North Brush Creek	3414	38%
31	South Cedar Creek	2003	36%
57	Middle Fork	5720	34%
61	North Rock Creek	7156	37%
66	East Medicine Bow River	2526	33%
28	North Cedar Creek	1475	32%
60	Forumile Creek	3107	29%
39	Lower South French Creek	1750	28%
56	South Fork	2216	27%
36	North Cottonwood Creek	1411	26%
35	Lower Brush Creek	1824	23%
67	Wagonhound Creek	1291	21%
SNOWY RANGE SOUTH			
50	Upper Douglas Creek	5802	55%
49	Devils Gate Creek	2562	40%
52	Bear Creek	3931	39%
44	Lower Douglas Creek	3023	27%
48	Middle Douglas Creek	2626	25%
45	Mowberg Creek	1492	24%
53	Lake Owen Creek	3394	23%
41	Cottonwood Creek	1597	21%
42	Platte River	3184	20%
51	Boswell Creek	1698	20%
43	Pelton Creek	3789	19%
46	Lake Creek	1757	18%
47	Muddy Creek	864	14%
40	Mullen Creek	1252	7%

The distribution of dwarf mistletoe in lodgepole pine is related to fire frequency and intensity (Zimmerman and Laven 1984) and the presence of dwarf mistletoe in stands reciprocally affects vertical and horizontal spread of fire because it causes accumulation of dead needles and branches (Hawksworth 1975). Fire eliminates dwarf mistletoe, and the interactions between the two are complex and need further investigation. Interactions of dwarf mistletoe and fire may also select positively for cone serotiny (Alexander and Hawksworth 1976).

Dwarf mistletoe responds well to increased light when lodgepole pine stands are thinned, and parasitic infection evidently intensifed greatly in cutover areas of the MBNF after tie hacking began about 1867. This effect was amplified in the landscape context by effective fire suppression after about 1910. Thus, mistletoe infection has been increasing for nearly a century (circa 1870 to 1950). Clearcutting greatly reduces dwarf mistletoe infection in regenerated trees and is one of the reasons for clearcutting in lodgepole pine on the MBNF. Dwarf mistletoe causes substantial damage and mortality in sapling and pole sized trees and affects growth and yield of merchantable timber in the 40-100 years age range. However, old growth lodgepole pines tolerate dwarf mistletoe parasitism with little effect on growth rates, although infected trees have about twice the mortality rate of uninfected trees (Hawksworth et al. 1992).

- Mountain Pine Beetle

General stand characteristics associated with epidemics of mountain pine beetle in lodgepole pine are 1) trees more than 80 years old, 2) average tree diameter more than eight inches, 3) a substantial number of trees in the stand with a minimum of 12 inch DBH and phloem 0.10 inches thick, and 4) elevations where temperatures are optimum for brood development (Amman 1978; Bentz et al. 1991). Climate becomes an overriding factor at high elevations when brood development is not synchronized with winter conditions (Amman 1977). Infestations in the southern part of the overall range of lodgepole pine (where the Medicine Bow National Forest is located) are usually light, resulting in low tree mortality (Amman 1978).

The report on the Medicine Bow Forest Reserve (1905) stated that "It [lodgepole pine] is almost immune from insect attacks" (USDA, 1905). Evidently major problems with pine beetles were not observed during the 1860-1900 era. While forests on the MBNF are not really "immune" to insect attacks, behavior of mountain pine beetle infestations and information on mountain pine beetle biology suggests that the high, cold environment of the Medicine Bow and Sierra Madre Mountains may inhibit synchronous development of high mountain pine beetle populations over large areas.

Most lodgepole pine forests on the MBNF are over 8000 feet in elevation compared to lodgepole pine forests at much lower elevations further north in Montana, Idaho, and Canada where there is less dramatic temperature variablity. Bark thickness may also be a limiting factor for beetle larvae survival during temperature fluctuations since lodgepole pine is thinner-barked than ponderosa pine (Amman 1977).

Stand susceptiblity of lodgepole pine to mountain pine beetle infestations was predicted, based on elevation and latitude relationships and on percent survival of infected lodgepole pine nine inches DBH or greater related to elevation (Amman et al 1977). At 41 degrees north latitude for the MBNF, stands of lodgepole pine above 8500 feet are at moderate risk (25-50 percent mortality) while stands above about 9500 feet are at low risk ($<$25 percent mortality).

The prediction for tree survival for trees nine inches or larger from mountain pine beetle infestation on the MBNF is about 68 percent to 90 percent between 8500 and 9500 feet based on models in Amman (1977). Elevation and latitude are not the only factors included when calcuating risk, but these data suggest that mature lodgepole pine forests here, at least those above 8000-8500, feet are probably not at high risk for mountain pine beetle infestations.

Habitat type is correlated with the degree of lodgepole pine susceptiblity to infestation with mountain pine beetle. Lodgepole pine stands with *Vaccinium* understories in western Wyoming and southeastern Idaho had the lowest infestation rate and loss to pine beetles among three habitat types evaluated. Infestation rates of stands with *Vaccinium* understories were only about half of the rate of stands with pinegrass or *Pachistima* understories (Amman 1977). *Vaccinium* is predominant community type on the MBNF; neither pinegrass nor *Pachistima* community types are common.

Older trees ($>$150 years) in thinned lodgepole pine stands appeared to be resistant to pine beetle attack (Preisler and Mitchell 1993). Mitchell (1989) pointed out the need for landscape management of lodgepole pine that preserves diversity in tree age and species and stocking over broad landscape areas to help control widespread mountain pine beetle outbreaks. Diversity both within stands and between stands dampens the opportunity for beetles to develop large populations. Good stocking control and healthy trees discourage beetle attacks, even in stands with moderate to large size trees.

Mountain pine beetle (*Dendroctonus ponderosae*) infestations of lodgepole pine were minor in the recent Laramie Peak bark beetle epidemic compared to infestation levels in ponderosa pine (1988-1994). Although small pockets of mountain pine beetle infestation occur throughout the Medicine Bow and Sierra Madre Mountains at endemic levels, no record of major epidemics was found

within the National Forest Boundary. In the early 1970s several areas were harvested where infestations were believed to be building (North Spring Creek and Green Ridge in the Sierra Madre). The most likely places for population buildup of mountain pine beetles in lodgepole pine is at warmer, lower elevations such as these. Beal (1943) reported an infestation near Elk Mountain 1932-1939 in lodgepole pine and limber pine.

-Other Diseases and Disturbance Interactions

Armillaria root disease occurs in local small areas of lodgepole pine in the Medicine Bow National Forest, but has not been historically a serious forest health problem (Geils personal communication). Western gall rust is found in some areas (Geils personal communication).

An hypothesis for interaction of fire, decay fungi, and bark beetles was suggested by Gara et al. (1984). The study area was in the pumice plateau of south-central Oregon, where an 1898 fire spread among downed and decaying logs of a lodgepole pine climax forest originating in 1839. Roots of residual trees, damaged by the fire, were subsequently invaded by two different types of decay fungi, which also infected tree boles. Sixty years later, the fungal-infected trees, which had been root-damaged by the surface fire, were preferentially selected by mountain pine beetles, further contributing to thinning of the stand. Clumps of seedlings developed in the canopy gaps formed by beetle-killed trees. One possible next step could be a stand-replacing fire. Another scenario is that minor, but frequent mountain pine beetle disturbances could facilitate canopy gap formation, contributing to stand diversity for an indefinite time.

Ponderosa Pine Forests

Ponderosa pine is a very common species on the Front Range in Colorado, but has limited population distribution on the MBNF. It is found mainly south of LaBonte Canyon in the Laramie Mountains and in the eastern part of the Sherman Mountains (Figure 6.1 c,d), (Photos E54,57,58). Small populations of ponderosa pine are found on Sheep Mountain, near or outside the Forest Boundary at the north end of the Medicine Bow Mountains, and at lower elevations of the Sierra Madre Mountains.

Very old individuals of ponderosa pine (300-400+ years old) can be found over a substantial area in the Laramie Mountains. They are common in the Ashenfelder Basin and nearby watersheds. Numbers of old live trees have declined sharply since 1988 in the wake of the mountain pine beetle epidemic, salvage logging, and removal of "overmature" timber on state, private, and National Forest system lands.

- Dwarf Mistletoe

The northern extent of the range of ponderosa pine dwarf mistletoe (*Arceuthobium vaginatum*) is in northern Colorado. Although birds can transport dwarf mistletoe seeds, its distribuition is thought to be limited by temperature factors. Most ponderosa pine populations are in the Sherman Mountains or southern Laramie Mountains and are physically isolated from main populations of ponderosa pine further south in Colorado. Dwarf mistletoe is not a problem in ponderosa pine populations of the Medicine Bow National Forest (Hawksworth and Weins 1972).

- Mountain Pine Beetle

The major insect pest of ponderosa pine in the Medicine Bow National Forest is the Mountain Pine beetle (*Dendroctonus ponderosae)*. It vectors blue-stain fungi (*Ceratostomella montia* and *Europhium clavigerum*). Beetle larvae damage phloem tissue, and the fungus blocks water transport in the trees xylem, causing death of trees in the spring and early summer the year after infestation. Effects of bark beetle epidemics are discussed in Schmid and Amman (1992). Work was done on mountain pine beetles (Black Hills beetle) throughout the Rocky Mountain Region by the Fort Collins Insect Laboratory from 1935 to 1960 (McKnight 1960a, 1960b). Specific references to studies on the Medicine Bow span the period 1938 to 1956. Unfortunately these studies were not located, but may be archived in the basement of the Rocky Mountain Station in Fort Collins. Ten ponderosa pine mountain pine beetle epidemics were documented and discussed by Beal (1943) (Table 6.2). Most pine beetle epidemics recorded by Beal (1943) were during series of dry years.

Table 6.2 Outbreaks of the mountain pine beetle 1895-1943 (Ponderosa pine unless otherwise noted (Beal 1943).

Place	Dates	Duration
Black Hills	1895-1908	14 years
Black Hills	1934-1939	6 years
Roosevelt National Forest	1923-1930	8 years
Roosevelt National Forest	1933-1939	7 years
Denver Mtn Parks	1932-1939	8 years
Pike National Forest	1932-1939	8 years
Montezuma Natl Forest (Southern CO)	1931-1936	6 years
Elk Mountain (Wyoming) (limber and lodgepole)	1932-1939	8 years
Dixie and Powell National Forests (Utah)	1916-1925	10 years
Dixie and Powell National Forests	1934-1939	6 years
Kaibab National Forest	1917-1926	10 years

Not all older trees are killed during mountain pine beetle epidemics. A site of infestation during the 1965-1977 Front Range epidemic was studied in Lory State Park west of Fort Collins. This was near the northern end of an infestation that extended south along the Front Range from near the Colorado-Wyoming line (McCambridge et al. 1982). Elevation ranges of at Lory State Park were 5480-7015 feet on 1220 acres in the study area. The mean age of trees in this stand was about 100 years. Trees down to one-inch diameter were infested and killed, with the greatest number infested at 9-15 inches diameter breast geight (DBH). Twenty-five percent of trees taller than 4.5 feet were killed. Age data were not given. There was a drop in percent of tree mortality in the 14- and 15-inch diameter classes, but few trees were killed in diameter classes up to 35 inches. Data were not provided as to the number of large trees or the age of infested or uninfested trees in this report.

Interactions among fire and mountain pine beetle cycles are not well understood. In the 40-year period (1954 to 1994) since the Black Mountain Fire Lookout was built on the Douglas Ranger District, fire suppression became quite effective in the Laramie Peak area. Dense cohorts of younger trees created competition with each other and with old trees (Photo E-64). The competition for space, water, and nutrients, combined with drought conditions and warm temperatures in the 1980s, likely stressed ponderosa pines of all ages, creating favorable conditions for a population explosion of mountain pine beetles. Severe mortality of trees of all ages and size classes resulted from the 1988-1994 pine beetle epidemic in the Laramie Mountains. Trees were mainly affected on lower slopes in the vicinity of Laramie Peak (Photos #57, 58). In some areas, patches of trees died, but widepsread mortality did not occur.

Specific evaluations of the Laramie Peak pine beetle epidemic have not been completed at the Regional Office. This may have been a major epidemic that could be expected perhaps every 500 years or more (Brown personal communication). Another possibility is that a half-century of fire suppression allowed the density of younger and submature trees to increase to where beetle populations became excessively high because of available host trees. High infestation rates combined with a drought period and a weakening of natural "pitch out" defenses due to water deficit from climate and competition may have played a part in the heavy mortality of trees.

Populations of older age classes (>200 years) have been severely reduced in the wake of the 1988-1994 epidemic. In 1994, seedlings, saplings and submature trees were apparent in most landscape positions. Aspen was vigorously growing in many riparian areas and on north-facing slopes. Forbs and grasses were luxurient after a wet spring in 1994. In inaccessible areas which are not salvage logged, large amounts of downed woody material will provide organic matter and increased fuels to the ecosystem for a long time.

- Other Diseases

Armillaria root disease is present, but not prevalent, in ponderosa pine in the Laramie Mountains (Geils personal communication).

Limber Pine Forests

Limber pine is found from lower to upper timberline in all four mountain ranges on exposed, windy sites with thin soils (Photos E55, E78)). It associates with lodgepole pine, ponderosa pine, and juniper. Limber pine is not a commercial tree species. Very large individuals occur in the Sherman Mountains and the Sierra Madre Mountains, but no age data on specific individuals are known from these mountain ranges. A limber pine on Sheep Mountain was dated as at least 514 years old in 1992 (Earle personal communication). Limber pines in Arizona and New Mexico may be 1600 or more years old (Swetnam and Brown 1992).

Douglas Fir Forests

Douglas fir has very limited occurrence on the MBNF in contrast to widespread populations in Colorado. Populations of mature Douglas fir near the Colorado/Wyoming border have been removed by clearcutting in the last 25 years on the Colorado side (Cartwright 1994). Douglas fir was probably more common in the southern Medicine Bow Mountains, Sherman Mountains and Laramie Mountains in the past, based on remnant populations and present vigorous reproduction on north-facing slopes. This species usually grows in about the same elevation range and geographic area as ponderosa pine, but on north-facing slopes. Populations of Douglas fir are found on north-facing slopes in the Platte River Canyon (Photo E-30), in lower Savage Run Creek, on Sheep Mountain, in the Sherman Mountains (Photo E53), and in LaBonte Canyon of the Laramie Mountians.

Diseases and Insect Infestations

Douglas fir is susceptible to spruce-budworm. There has been at least one recorded outbreak, at low elevations along the Platte River in the late 1920s (Hilton 1930).

Rocky Mountain Juniper Woodlands

Rocky Mountain juniper woodlands are found in scattered locations at lower elevations, but do not cover large areas. The Platte River Canyon, Sheep Mountain, and portions of the southern Laramie Mountains contain juniper woodlands within the National Forest Boundary. Although the cover type is classed as pinyon-juniper in the RIS database, no pinyon pine has been found on

the MBNF. The nearest occurrence of pinyon pine is in the Uinta Mountains of southwestern Wyoming (Little 1971). Juniper woodlands are associated with big game winter range consisting of big sagebrush, antelope bitterbrush, and bunchgrasses.

FOREST COMMUNITY TYPE CLASSIFICATION

Nine forest habitat types were identified for the MBNF by Alexander et al. (1986). No attempt was made to estimate acreages or create a map. Habitat types are artificial vegetation categories constructed on criteria of landform, soils and vegetation. Community types are described on the basis of vegetation only. Both methods use overstory/understory labels based on the first two letters of genus and species names (i.e. Pico/Vasc = *Pinus contorta/Vaccinium scoparium* = lodgepole pine/vaccinium).

The working list of community types in Appendix 6 provides a menu of overstory/understory combinations for both upland and riparian vegetation on the MBNF. While habitat typing tends to group different vegation assemblages into broad categories, the community type list provides descriptors which emphasize diversity. For example, Alexander et al. (1986) described five habitat types for lodgepole pine while the community type list suggests 15 distinct overstory/understory combinations. Coniferous forest community types include 19 upland and 22 riparian spruce, fir, or spruce-fir community types; 13 upland and two lodgepole pine community types; and 14 upland and three ponderosa pine riparian community types. Acreage estimates and mapping of these habitat types, community types, and others yet to be described, lies in the future.

FIRE IN CONIFEROUS FORESTS

FIRE STUDIES

The literature on fire in spruce-fir, lodgepole pine, and ponderosa pine forest systems in the Western United States is huge, but fire studies on coniferous forest ecosystems of the Rocky Mountains of Colorado and Wyoming are few. Fire studies on lodgepole pine, spruce-fir, and spruce forests in the Medicine Bow Mountains include Stahelin 1943, Billings 1969, Romme and Knight 1981, and Honaker 1995. All were done in forests above 8800 feet. No studies have yet been done on ponderosa pine fire history in the Laramie Mountains or Sherman Hills, although an excellent opportunity exists for this in the Ashenfelder Basin proposed Research Natural Area.

Some fire studies of coniferous forests of the Colorado Front Range include Alexander 1975, Laven et al. 1980, Veblen and Lorenz 1986, Franklin and Laven 1989, Veblen and Lorenz 1991, Goldblum and Veblen 1992. Some fire studies

of lodgepole pine and spruce-fir ecosystems of Yellowstone National Park, both preceding and since the large fires of 1988, are Romme 1980, Romme 1982, Romme and Knight 1982, Romme and Despain 1989, Greater Yellowstone Postfire Ecological Assessment Workshop 1989, Renkin and Despain 1991, Turner and Romme 1993. Southwest ponderosa pine has been studied by researchers in the southwest, including: Weaver 1951, Cooper 1960, Dieterich 1983, Covington and Moore 1994. Recently fire scar studies have been done for parts of the Black Hills (Brown 1994).

FIRE MODELS

Elevation has two general effects on fire regimes in coniferous forests of the Rocky Mountain area:

1. As elevation increases, mean fire return intervals decrease
2. As elevation increases, fire intensities increase

Fires may be catastrophic (stand destroying canopy fires) or surface fires. Intense catastrophic fires which occur less often are more likely at high elevations, while less intense but more frequent surface fires are more characteristic of lower elevations.

Three of five major tree species on the MBNF are adapted to fire. Lodgepole pine has serotinous cones, mostly branch-free boles, a rapid growth rate, precocious cone production on young trees, and shade-intolerance. Ponderosa pine has thick exfoliating bark when burning, branch-free boles, shade-intolerance, and grows at warm, low elevations where surface fires are fairly frequent. Low-intensity surface fires maintain an open understory and generous tree spacing. Individuals are long-lived. Mature aspen trees are sensitive to both surface and crown fires, but vigorously reproduce from surviving below-ground parts when dominant trees are removed. For ponderosa pine and aspen, the parent survives fire; for lodgepole pine, the offspring survive fire. Engelmann spruce and subalpine fir are not fire adapted.

Fire suppression has had major effects on stand structure and fire behavior in ponderosa pine ecosystems throughout the western United States, setting the stage for catastrophic canopy fires because of fuel buildup from needle-drop and increase in herbaceous and woody fuels. Fires in ponderosa pine ecosytems are believed to have historically been relatively frequent surface fires (from less than a decade to several decades), rather than catastrophic canopy fires which destroy stands on the order of every 50 to 300 or more years, as is believed characteristic of lodgepole pine or spruce-fir.

Fire suppression has not had much effect on fuel loads in high-elevation spruce-fir systems, which ordinarily have heavy fuel loads anyway and infrequent, but usually catastrophic fires (Laven 1995). This kind of fire regime creates patches of forest with distinct age classes. With long fire return intervals, most of the landscape remains in mature forest for long periods.

Fire suppression effects on lodgepole pine systems are harder to evaluate in relatively short time frames (less than 100 years) because of interactions with mistletoe and bark beetles and the necessary substitution of place for time to make inferences. Variation in "natural" extent and frequency of fires in lodgepole pine and spruce-fir systems is not well understood for central and southern Rocky Mountain ecosystems.

In any discussion of fire regimes in different forest types, there is danger of oversimplification and overgeneralization. A basic characteristic of biological diversity is to identify differences in ecosystems and processes, rather than seek homogenization of ecosystems and processes based on a few dominant characteristics. Generalizations about ecosystems and processes obscure understanding of biological diversity because they create a false concept of biological homogeneity, which does not exist when ecosystems are measured or described at smaller scales with more detail.

Examples of simplification and homogenization applicable to forest structure and processes include generalized forest life history diagrams such as those for lodgepole pine which imply that lodgepole pine forests burn at or soon after reaching maturity and are most often subject to high levels of mistletoe or pine beetle infestation (Figure 6.11). General fire diagrams such as Figure 6.12 imply similar homogeneous mechanisms of forest behavior which are not appropriate or applicable for describing biological diversity.

While diagrams such as Figures 6.11 and 6.12 are useful as a general conceptual tool, they do not portray the variation in length of time between purported stages of forest development. They impart a mechanistic view of processes and tend to homogenize thinking about forest structure and dynamics, rather than show variation in forest structure and processes. They do not portray landscape properties of forest succession and fire effects or show the diverse within-stand effects of fire and succession, and they do not account for effects of stochasticity. They treat fires as ""all or nothing" events, which is not the case.

This can create a concept of much simpler forest systems than actually exist. As more data have become available and knowledge increased, more variablity has been found for many kinds of forest structures and processes. Forest structures and processes can be stratified by time period, and they can be sorted into groups by elevation, latitude, topographic position, slope steepness, aspect, community

type and so forth. Any individual site will also be influenced by local history, topography, and chance events.

Fire behavior in different habitat types was categorized by Crane (1982) and Bradley (1992). This included fire responses of major understory components and facilitated description of some of the diversity of effects fire can have on various community types. Crane (1982) divided forest and woodlands in Region 2 into 17 fire groups, based on overstory/understory species and habitat characteristics. For example: warm, dry ponderosa pine habitat types, warm moist ponderosa pine habitat types, northern Colorado and Wyoming subalpine fir and spruce stands, and very moist spruce and subalpine fir habitat types. This approach, although it lacks a temporal framework, is more useful than generalized cover type models for evaluating interactions between fire and biological diversity.

Mean fire return interval is a statistic often used to characterize the "range of natural variability" for fire. This statistic gives information on means, rather than actual ranges of time between fires, and while useful as a general framework, if taken too rigidly may obscure important variation. It is becoming apparent, as more data are gathered, that there is a high variance that accompanies this statistic.

The variability of fire occurrences may have more relevance to biological diversity than the mean fire return interval. A mean fire return interval of 50 years over a period of 300 years might mean fires every 50 years (six fires) or perhaps fires might occur at 100 years, 50 years, 25 years, 12 years, 100 years and 13 years. These two schedules would not produce the same ecological effects.

In southwestern ponderosa pine systems the variablity in recurrence of surface fire around a mean fire return interval is fairly low (5-12 years for example). In ponderosa pine ecosystems of northern Colorado surface fire mean fire return intervals may be in the order of 50-60 years (Laven et al. 1980), but the variablity in actual occurrence may span a much longer or shorter time.

Mean fire return intervals (for surface fires) are based on tree ring records for ponderosa pine forests. Mean fire return interval may be more regular and more meaningful in ponderosa pine cover types than lodgepole pine or spruce-fir cover types. For lodgepole pine and spruce-fir mean fire return intervals are usually estimates based on stand age following stand-destroying fires.

Stand age may be a reasonable approach to fire history analysis for lodgepole pine, which is not shade-tolerant, is rather short-lived, and often forms a (fairly) even-aged stand. Stand age may indicate an only minimum fire return interval for spruce-fir forests. Spruce-fir forests may be older than the oldest living trees, since the oldest living trees may represent only the oldest individuals of the

current generation. Time since actual stand origin is often not known. Old spruce and fir trees are hard to age accurately because of their size and the pithiness of boles, and the ecosystem they are part of may have a longer history of forest continuity than the life span of existing trees. Laven (1995) is exploring use of phytoliths (opaline crystalline structures associated with leaf tissue) which can be carbon dated to obtain a better idea of fire return intervals in cold, high-elevation systems.

With the above caveats, some mean fire return intervals for ponderosa pine, lodgepole pine, and spruce-fir in Rocky Mountain ecosystems are shown in Table 6.3.

Care must be used when comparing fire data for a given cover type when data are from other areas. Assuming that lodgepole pine forests on the Medicine Bow Mountains will have a fire regime like lodgepole pine forests on the Bitterroot National Forest, which has different understories, lower elevations, hotter, drier summers, a history of severe mountain pine beetle epidemics, and a different climate, may lead to erroneous conclusions about lodgepole pine ecosystem behavior and diversity on the MBNF.

Table 6.3 Mean fire return intervals (MRI) for selected areas in the Western United States

Place	MRI	Cover Type	Ref
Bitterroot NF, MT	6-11	ponderosa pine	Arno (1976)
Black Hills, SD	9-79	ponderosa pine	Brown (1994)
Boulder, CO	3-49	ponderosa pine Douglas fir	Goldblum and Veblen (1992)
Roosevelt NF	5-157 Douglas fir	ponderosa pine	Laven et al. (1980)
San Juan NF	3-55	ponderosa pine	Romme et al (1994)
Arizona	5-12	ponderosa pine	Weaver (1951)
Yellowstone	150-300+	spruce-fir	Romme & Despain (1989)
Northern Rockies	63-153	spruce-fir	Arno (1980)
General	100-300	lodgepole pine	Hendrickson (1972)
Medicine Bow NF	300+	lodgepole pine spruce/fir	Romme and Knight (1981)

The same caveats apply to spruce-fir fire return interval statistics from areas which have northern boreal forest characteristics such as fairly frequent

catastrophic burns (circa 150 year cycles), as opposed to Rocky Mountain subalpine settings.

PRE-SETTLEMENT FIRES

Influences of Native Americans on grassland and low elevation mountain ecosystem fire regimes of the Rocky Mountain west in the past 1000 years have been studied in many places. Specific conclusions are often elusive, and it is not possible to separate "natural" fire regimes from influences of Native Americans since the end of the Pleistocene (Martin and Sapsis 1991). The mobility conferred on Indians in the Great Plains and Intermountain Areas by acquiring horses in the early 1700s had a major effect on the distribution and use of fire by Native Americans. Among other reasons, Native Americans used fire (mainly in grassland and shrubland systems) to drive game for capture, to reduce competing shrub vegetation, and for warfare with each other and against white emigrants and settlers (Williams 1993).

Effects from Native American-caused fires in the 1700s and 1800s were widespread in lower elevation forests in western Montana and the southwest (Barrett 1980; Barrett 1981; Barrett and Arno 1982; Gruell 1983, 1985; Savage 1991). Human-caused fires in upper elevation subalpine fir and lodgepole pine in Montana were apparently not common except in local habitation zones or along travel routes (Gruell 1985). Human-caused fires may have commonly spread upward into lodgepole pine forests from lower elevations. These fires were probably small except during weather extremes or where fuels were continuous (Gruell 1985).

Periods between fires, and variability in fire characteristics, may have been reduced by Native Americans, compared to fires started by lightning alone, because they could start fires any time conditions were right, and could choose the sites for fire starts (Martin and Sapsis 1991).

Considerable topographic constraints to travel through the mountains are found on the MBNF. Travel circumventing the mountains, using the plains, was easiest. In historic times (since 1600) the plains and mountain foothills were the scenes of many battles and probably fires. Travel routes such as the Park Pass Trail across the Medicine Bow Mountains in the vicinity of Highway 130), the Laramie River Canyon, the Crow Creek Trail in the Sherman Mountains, north-south routes through the Laramie Mountains (Fetterman Road alignment), and east-west routes across the Laramie Plains are likely places for Indian-caused fires to have occurred.

Lower elevation parks such as Friend Park, Cottonwood Park, Harris Park, and the Esterbrook area in the Laramie Mountains have agreeable climate and

vegetation for habitation by Indians and contain evidence of Native American use. Parkman (1950) mentions that Indians ate gooseberries and currants (1846), which suggests that the country in the Laramie Range was open and had fire-adapted shrubs. Review of Native American presence (1600s to mid-1800s) in the vicinity of the present MBNF is in Grasso et al. (1981).

There is little evidence of Native American use of high elevations in the Snowy Range or areas of rugged topography, but these areas have not been well-studied by archaeologists. It appears that human-caused fires circa 1600-1850 were most likely around the edges of mountain ranges and in the lower elevation areas of the Laramie Mountains. Human caused surface fires may have been frequent in or near open ponderosa pine forests of the Sherman Mountains and Laramie Mountains. Canopy fires may have occured with more frequency in the Sierra Madre or Medicine Bow Mountains where lodgepole pine forests border grasslands and shrublands, or occur in canyons.

THE HISTORICAL FOREST

Indications from historical records, from stand origin data in the RIS database, and from the few available local studies (Romme and Knight 1981; Honaker 1995) are that mature, closed canopy, coniferous forests were widespread in the Medicine Bow and Sierra Madre Mountains prior to 1860. These mature forests formed the matrix of the landscape between the sagebrush and juniper zones at lower timberline and upper timberline at about 10,500-11,000 feet. The attractiveness of these forests to tie-hacking in every major drainage tributary to the Platte River system suggests that they contained mature lodgepole pine.

Fires at high elevations were likely very infrequent and most areas had stand continuity for a minimum of 400 to 600 years. Lower elevations had many stands in the 200-400 year old range. Oldest stands of trees were usually in riparian areas at any elevation. Small patches of disturbance from fires or blowdown (on a landscape scale) undoubtedly occurred and were probably more numerous at lower elevations (7000-9000 feet). Occasional blowdowns occurred at high elevations (two have been recorded in the last 100 years).

The southern part of the Laramie Mountains (from approximately LaBonte Canyon southward) and the Sherman Mountains is inherently patchier than the Medicine Bow Mountains, with many upland perennial grasslands forming the mosaic due to both variation in substrate and disturbance. Surface fires maintained an open condition beneath savannas of large ponderosa pines in level areas and on south, east, and west slopes. North slopes with Douglas fir likely had infrequent stand-destroying fires restricted by topography and the cool, moist environment of north-facing slopes.

Presettlement forests in the southern Laramie Mountains were probably more open, with larger trees, than today. Suppression of surface fires in the past 50 years in the ponderosa pine ecosystems of the Laramie Mountains has contributed to a high buildup of ladder fuel from seedling, sapling, and pole-sized trees, especially in rugged areas. In the absence of fire suppression presumably more and/or larger patches of open understory would exist. Fuel buildups from herbaceous and shrub vegetation are not significant where cattle gain entry. The presettlement forest vegetation of the Sherman Mountains is largely unknown, except that it was forested.

The landscape context for fires in the southern Medicine Bow Mountains, the canyons on the west side of the Medicine Bow Mountains, and the Sierra Madre likely is very different now than before 1850. Patchiness of age class and structure caused by clearcutting; local areas of severe mistletoe infestation which have developed in the past 150 years; thick understories of lodgepole pine or subalpine fir under aspen, or subalpine fir and spruce under lodgepole pine; roads; and removal of fine fuels by livestock are changes which have occurred in the past 150 years. Some of these changes inhibit ignition and spread of fire, while others may encourage fire.

Landscape contexts for fire in uncut spruce-fir forests are probably not changed very much from historic conditions. The landscape context for fire in strip-clearcut high elevation spruce-fir forests has changed substantially for the northwest Medicine Bow Mountains (Brush Creek District) because large areas have altered fuel characteristics.

FIRE IN CONIFEROUS FORESTS OF THE MBNF

Lodgepole Pine and Spruce-Fir Forests

Historical fire behavior (mid 1400s to present) was evaluated on three drainages in Savage Run Wilderness in the late 1970s (Romme 1977; Romme and Knight 1981). Sites for fire studies were located in the headwaters of south Mullen Creek, Savage Run Creek, and Cottonwood Creek within the present Savage Run Wilderness Area. Old lodgepole pine forest (280-400 years old) and old spruce-fir forest (300 to approximately 640 years old) dominate the area. Lodgepole pine (some areas with an understory of spruce-fir) occurs mainly on ridgetops and slopes, while spruce-fir forms a riparian forest in the valley bottoms. The conclusions reached by Romme in his Master's Thesis study were:

1) fire is less frequent in drainage bottoms, thus permitting development and persistence of spruce-fir forest and

2) succession is slower on the slopes and ridgetops, thus encouraging the presence of lodgepole pine forests.

Development of spruce-fir forest in the context of time and topographic gradients is shown in Figure 6.13 (Romme and Knight 1981).

Fire history of lodgepole pine and mixed conifer forests in the Coon Creek drainage, the East Fork of the Encampment River, and portions of adjacent watersheds in the southern Sierra Madre Mountains was examined by Honaker (1995). The purpose of this study was to ascertain fire frequencies, fire intervals and patch size in coniferous forest between about 8800 feet and 10,000 feet to contribute to information on the "range of natural variability."

Spruce-fir forest components in the oldest age classes tended to be in riparian areas in Honaker's study also. When cumulative polygon acreage was plotted against years (Figure 6.14), four possible times of presettlement stand-replacing fires were suggested from the presence of remnant old forest. The four areas were in four different parts of the study area and did not overlap. The data used for Figure 6.14 is from the MBNF RIS database. Tree ring cores (Honaker 1995) were compared with stand origin dates in RIS. The RIS stand origin dates were close to tree ages measured by Honaker in most cases. Dates and acreages are shown in Table 6.4.

Table 6.4 Approximate year of origin and remnant patch size for fire history in a portion of the Encampment River Watershed (Honaker, 1995).

YEAR	AGE in 1994	ACRES IN LARGEST REMNANT
1692	303	308 acres
1791	204	523 acres
1824	171	302 acres
1855	140	430 acres

From these data it is not possible to say for certain how large the fire patches were for the southern Sierra Madre study area. Most trees with fire scars had only one scar. Because older trees are often pithy in the center and accurate dating is impossible, there are serious limitations to projecting fire histories beyond the mid 1700s in lodgepole pine/spruce-fir systems. Stand origin dates are approximate, especially older dates, since dating of tree ages becomes less precise for older trees and stands may be older than existing trees.

Burn areas on Libby Flats were studied by Stahelin (1943) as part of a survey of high-altitude burns in Colorado and Wyoming. This site is above the lodgepole

pine zone. Stahelin dated the burn at this site at 1880 and observed that subalpine meadow constituted the seral stage. He concluded that the dense turf of sedges and grasses which formed on burned-over areas was an effective barrier to the establishment of conifer seedlings and that the meadows would maintain themselves for centuries. This long-lasting seral stage is essentially a type conversion (forest to subalpine grassland) with respect to management and forest planning timeframes. Billings (1957) reached the same conclusion after studying another area of Libby Flats.

Fire history of high altitude forests in the Medicine Bow Mountains was evaluated by Billings (1969). He estimated a fire-free period in high elevation spruce-fir forests near the University Science Camp in the Medicine Bow Mountains to be at least 600 to 700 years. Other forested areas in the Medicine Bow Mountains appeared to have been destroyed by fire more than once in that period of time. This was based on pollen data collected by Sears (personal communication) and cited in the 1969 paper. Palynological analysis of wetlands in the Snowy Range might yield information on this, but no studies other than the reference to Sears' unpublished work have been located. Billings' dendrochronology records indicated lesser fires in 1766, 1774, and 1809. He suggested that the most recent fire was probably in 1871 (others have suggested 1868) in the vicinity of Libby Flats. Moir (personal communication) found Engelmann spruce trees in excess of 600 years old near the Sheep Lake trail, below timberline near Brooklyn Lake, northeast of Libby Flats.

Ponderosa Pine Forests

Fire history studies of ponderosa pine forests in the Laramie Mountains and Sherman Mountains have not been done. Preliminary evaluation (Brown personal communication) indicated that most ponderosa pines estimated to be 300 to 400 years old in the Fall Creek and Ashenfelder Creek drainages, had five fire scars. That would suggest a mean surface fire return interval of 60 to 80 years, similar to what Laven et al. (1980) found for the South Fork of the Cache LaPoudre River in Colorado. It appears that mean fire return intervals in the North Laramie Mountains may be somewhat longer than the Black Hills (Fisher et al.1987) and certainly much longer than for ponderosa pine ecosystems in Arizona and New Mexico. Surface fire patch size ranges are unknown.

Dominant ponderosa pines in the Ashenfelder Basin and nearby areas to the east were aged by Sobczak (1987) and Jones (1989). The 42 trees represented in Figure 6.14 are from an area of about 25 square miles northeast of Laramie Peak - from the north end of Rock Mountain and The Limestone, to Salt Lick Creek in the Ashenfelder Basin. The relationship of tree germination and diameter breast height for trees germinating between 1600 and 1870 is very poor. There can be a 200+ year age difference among ponderosa pines of similar size.

This graph was prepared to see if cohorts of trees which may have germinated at about the same time, possibly in response to climatic factors, might appear as clusters of trees about the same age. This assumes absence of crown fires during this period and approximately equal area-wide impacts from insect attacks or storms. It appears that there may have been a hiatus in tree recruitment between 1700 and 1730. This could be from lack of establishment or from mortality. Between about 1755 and 1775 there appears to have been a high recruitment or better survival of trees living until at least the late 1980s.

Fire hazard temporarily increased during the 1988-1994 pine beetle epidemic because of fine fuels from dead pine needles. Now there are few standing trees with needles, and pine needles on the ground are beginning to decay. There is high biomass production among grasses, forbs, and shrubs, which also provide substantial ground-level fine fuels. After a new cohort of trees is produced and grows to sapling and pole heights, fire risk will be increased.

THE "RANGE OF NATURAL VARIABILITY" OF FIRE

Firm conclusions cannot be drawn about either what is "natural" or exactly what occurred before about 1850. A literature review on RNV information applicable to the Routt National Forest is in preparation (Neelan et al. 1994). An extensive review of literature on the range of natural variation in the Colorado Front Range and associated grasslands was completed in July, 1994 for the Arapaho-Roosevelt National Forest by Covich et al. at Colorado State University. They concluded that the range in natural variation in regional ecosystems has not been adequately studied, and that synthesis of information cannot be done from limited data presently available. Regional centers of long-term data are needed to provide Range of Natural Variation analysis of multiple sets of data that cover the same time periods in the same locations for many kinds of ecosystems (Covich et al. 1994).

FIRE HISTORY SINCE 1945

Medicine Bow National Forest fire records 1945-1992 were analyzed for information on differences in ignition rates from human-caused and lightning-caused fires in each mountain range. Size of fires which have actually occurred, given fire suppression, is also included in the data. Detailed discussion of these data, supporting the points below, is in Appendix 15.

These data do not suggest what is "natural" other than background ignition rates from lighting strikes. Even lightning ignitions may be altered some by human-influenced forest structure - for example presence or absence of slash, tree size and density, and availability of fuel types.

Forest Service fire classes range from class A (smallest) to class G (largest). Numerous size class A and B fires burned few cumulative acres compared to the seventeen size E and F fires during the 1945-1992 period (Figure 6.16). Human-caused fires predominate in the Medicine Bow Mountains; lighting-caused fires predominate in the Laramie Mountains, and human-caused and lightning-caused fires are about equal in the Sierra Madre Mountains and Sherman Mountains (Figure 6.17).

The following points summarize fire history information 1945-1992 for the MBNF:

1. There are substantial differences in fire causes and acreage burned among the four mountain areas.

2. Fire detection and suppression is very effective on the Medicine Bow National Forest inferred from the large number of class A and B fires.

3. The frequency of lightning ignitions in the Sierra Madre and Medicine Bow Mountains is low (standardized to ignitions per million acres).

4. The frequency of lightning ignitions in the Laramie Mountains and Sherman Hills is high (standardized to ignitions per million acres).

5. Human-caused fires outnumber lightning-caused fires in the Medicine Bow Mountains about 2:1, but lightning-caused fires in the Laramie Mountains outnumber human-caused fires by about 3:1.

6. There are few fires from either cause in the Sierra Madre or the Sherman Hills, and there were about equal numbers of each. All were class C or smaller (11-99 acres).

7. Of 17 large fires (classes E and F) since 1945, 11 were caused by lightning. There were 14 class E fires (300-999 acres) nine of which were lightning-caused (eight of them in the Laramie mountains) and five man-caused (four of which were in the Medicine Bow Mountains). Of the three class F fires, (1000 - 4999 acres), two were caused by man and one by lightning.

8. Fires in classes A-D account for 99 percent of the fires but only about 30 percent of the acres burned. Thus about one percent (17 of 1465 fires) burned about 70 percent of the acreage affected by fire since 1945. Eleven of these 17 fires (65 percent) were man-caused.

Future fires may or may not follow patterns of the past half century, since patterns of stand structure are continually changing as new harvest occurs, regenerated stands grow, and there is always a possiblity of large fires due to stochastic events.

FOREST STRUCTURE AND SUCCESSION

SPRUCE-FIR FORESTS

A classic study of spruce-fir forest structure was done in 1952 by University of Wyoming professors Oosting and Reed in old growth forests of the Snowy Range near the University Science Camp. They found subalpine spruce-fir forests generally occurred between 9800 and 10,600 feet in the Medicine Bow Mountains. Spruce lived longer than subalpine fir, but subalpine fir reproduced more prolifically. Their paper contains an excellent review of earlier studies on spruce-fir in Colorado and Wyoming and recognizes the value of spruce-fir forests for snow-catchment and protection of upper watersheds.

Spruce-fir forests occur at about the same elevations in the Sierra Madre Mountains. Small patches of spruce-fir forest occur in north-facing coves, at the head of canyons in the Sherman Mountains, on the upper parts of Laramie Peak, and locally in the northern Laramie Mountains. In the Laramie Mountains the association is more often fir-spruce forest, with dominance of subalpine fir.

Spruce-fir forests are floristically fairly simple in the Medicine Bow Mountains. Lodgepole pine and limber pine are the primary conifer associates. Elsewhere in the geographic range of Engelmann spruce it occurs with bristlecone pine, aspen, Douglas fir, corkbark fir, white fir, and even pinon pine (Oosting and Reid 1952).
Within-stand age structure adds diversity to forests. Age structure and successional dynamics of Colorado subalpine forests (Fraser Experimental Forest) were studied by Whipple and Dix in 1979. They found that subalpine forests varied over elevation and topographic moisture gradients and had a variety of understory types. The forest types were:

1. climax lodgepole pine
2. climax spruce-fir pioneered by lodgepole pine after disturbance
3. climax spruce-fir pioneered primarily by spruce.

The results are applicable to forests of the Sierra Madre and Medicine Bow Mountains.

No stand types had consistent within-stand species age structure. Age structure of stands differed because of varying environmental or historic conditions. Five types of age structures which result from various patterns of recruitment and mortality, regardless of species, were identified (Figure 6.18) (Whipple and Dix 1979). Thus, age characteristics of individiual stand populations adds considerably to within-stand biological diversity, even within seemingly similar stands.

Individual trees are aged to determine stand structure. Sometimes inferences regarding stand dynamics are made based on the age data. In a detailed study of lodgepole pine-Engelmann spruce forests in Alberta, Johnson et al. (1994) illustrated some problems of using static age structures to reconstruct stand dynamics and succession. They investigated two long-held dogmas regarding succession and stand structure:

1. the empty middle age classes in spruce-fir forests are the result of a period in stand development when recruitment was prevented

2. understory trees have replaced canopy trees.

Height-date curves were used by Johnson et al. (1994) to test four possible models of establishment and canopy recruitment (Figure 6.19). They found no evidence of any real stop in the number of trees recruited in the understory (i.e. many seedlings continued to establish through time), and that understory trees do not often enter the canopy in mature stands. In other words, a lot of trees germinate, which live for various lengths of time and grow to various sizes, but most die before becoming part of the canopy. Their results showed that forests must be viewed as a collection of species populations of cohorts stacked in time and size. Succession must be understood by studying the recruitment and mortalities of these cohorts. Their results applied to Engelmann spruce-lodgepole pine forests of about 60 to 225 years of age.

Veblen et al. (1989) examined the behavior of stand development in an old lodgepole pine stand (ca 200 years) with a spruce-fir understory in Rocky Mountain National Park. A blowdown in 1973, which affected the lodgepole pine canopy, released the spruce-fir understory, accelerating the development of spruce-fir forest. A similar stand-structure/successional dynamic could result from insect attack on lodgepole pine or selective removal of lodgepole pine by tie-hacking. Any selective removal of lodgepole pine would accelerate the development of spruce-fir forest from existing young spruce and fir trees, release growth in remaining mature lodgepole pines, and provide canopy gaps for germination of new lodgepole pine trees, thus increasing forest diversity and creating more complex stand structure.

In another study, west of Boulder, Colorado, Forsyth (1980) concluded that, despite the relatively homogenous appearance of the subalpine forest, there was substantial diversity in community and vegetation composition and structure when quantified data were analyzed. Five major understory types were identified by a principal components analysis of forests along a lodgepole pine/spruce-fir gradient on the Little South Fork of the Cache la Poudre River in the Roosevelt National Forest and Rocky Mountain National Park (Larsen 1978). The understory types were buffaloberry, common juniper, kinnikinnik, heartleaf arnica, and grouse whortleberry. Continuity of the understory did not match continuity of the overstory, and the results suggested that the present generation of overstory species was more a result of the distribution of old burns than any other environmental factor.

The equilibrium and spruce exclusion phase models are two contrasting views of long-term forest dynamics in spruce-fir forests. The equilibrium (climax) view suggests disturbances (other than catastrophic) cause only minor deviations from a true climax (equilibrium) state where spruce and fir coexist in a stable community dependent on the life-history characteristics of the two species. In contrast, the spruce exclusion phase model suggests there is a non-equilibrium coexistence of spruce and fir, and that over a long period of time (ca 600 years), there is a period of spruce exclusion (new spruce seedlings do not establish, and existing understory spruce trees grow slowly). Spruce reinitiation would occur during a wave of mortality in the overstory allowing second generation spruce trees to establish and become codominant with fir. Fir would continue to establish and occupy gaps throughout the lifetime of the forest, which may continue for many tree generations. See Aplet et al. 1988; Johnson et al. 1994)

The spruce exclusion phase model suggests that gap-phase dynamics having major effects on stand composition and structure may occur at predictable times as a function of the different life spans of spruce and fir interacting with disturbance agents. These dynamics occur over a period of several centuries (Aplet et al. 1988). In the absence of catastrophic disturbances, forest continuity may span many overlapping generations of trees which can live 300 to 500 years each.

The foregoing examples show that biological diversity, related to the structure and composition of different community types and disturbances of forest stands, is very complex. The details of how these various intra-stand arrangements interact with wildlife habitat and populations or other components of biological diversity are presently understood only in a very general context.

Various models of succession in spruce-fir forests have been offered in the literature as conceptual tools. Some of these successional models are shown in Figures 6.20-6.21. Stahelin's (1943) model of succession in spruce-fir forests is shown in Figure 6.20. Another model (Medicine Bow National Forest 1993) is

shown in Figure 6.21. This model applies to lodgepole pine and aspen. While these models are useful, they do not contain sufficient detail to provide much information on differences in biological diversity which may result due to differences in community types, they do not take sufficiently into account multiple pathways, and they are too general in time or spatial scales.

LODGEPOLE PINE FORESTS

Forest structure and stand dynamics have been studied for a long time in lodgepole pine forests. Clements wrote extensively on the life history of burned lodgepole forests and was an early advocate of "clean-cutting" in the lodgepole pine zone to ""be able to extend or restrict lodgepole reproduction and lodgepole forests at will" (Clements 1910). Much of the research on lodgepole pine forests comes from the Northern Region of the Forest Service. Several symposia have been devoted to the biology and management of this species (Baumgartner 1973; Baumgartner et al. 1984).

Four roles of lodgepole pine in stand development are 1) minor seral, 2) dominant seral, 3) persistent, and 4) climax were (Pfister and Daubenmire 1975) Figure 6.22. All four patterns occur on the MBNF. Lodgepole pine can form a seral forest prior to the establishment of Engelmann spruce and subalpine fir. On some topo-edaphic situations lodgepole pine is not replaced by spruce-fir (Moir 1969; Weidler 1995). Non-pyrogenous climax lodgepole pine stands are described for Yellowstone National Park by Despain (1983).

The environment which favors climax lodgepole pine forests is warmer and or drier than conditions which are good for spruce-fir forest development through succession. Despain argues that climax lodgpole pine forests do not need fire to persist or regenerate, but rather that they are sufficiently open and have adequate canopy gap formation so that lodgepole pine trees are continuously recruited. This forms a forest which is generally composed of large, tall, generally single storied trees, with smaller trees in gaps or sparingly dispersed among larger trees.

Climax lodgepole pine forests of the eastern slope of the Front Range in Colorado were described by Moir (1969). On the MBNF this kind of stand structure (tall, single-stored, closed canopy-open understory) is found in unlogged areas with old lodgepole pine in Savage Run Wilderness and in the Threemile potential Research Natural Area. It is also known from smaller areas in the Cedar Creek drainage, the Kennaday Peak area, and lower elevations of the northwestern Sierra Madre Mountains. This is not a common forest structure type on the Medicine Bow National Forest and few areas of large patches are found. Old, single-storied lodgepole pine forests, lacking significant spruce-fir understories, are prime habitat for northern goshawks (Squires, personal communication).

PONDEROSA PINE FORESTS

Successional models for development and persistence of ponderosa pine forests for the Front Range of Colorado and the Laramie Mountains of Wyoming have not been found in the literature. Moir and Dieterich (1988) developed an 11-step successional model for development of old-growth forests in ponderosa pine/bunchgrass habitats in Arizona and New Mexico (Figure 6.23). In that system, features of old growth ponderosa pine forest begin to develop at about 200 years after forest intiation, but are best expressed after about 300 years. A similar length of time for old growth ponderosa pine forest development may be necessary in the Laramie Mountains, however the community types and fire regimes in the Laramie Mountains are different than for Arizona and New Mexico.

FOREST PROCESSES AND FUNCTIONS

Research on water outflow, nutrient dynamics, and other forest processes on the MBNF is extensive, especially for lodgepole pine forests. Even with these, and numerous studies on conifer forests elsewhere, the story of how forests function is still being assembled.

FOREST HYDROLOGY

A detailed discussion of forest hydrology is beyond the scope of this report, but a brief review of literature and concepts will be provided because management of forests for hydrological purposes affects biological diversity, and timber harvest affects both hydrologic properties of ecosystems and biological diversity. On the MBNF there are two 9B Management Areas (water yield emphasis). These are Upper Douglas Creek (above Rob Roy Reservoir) in the southern Medicine Bow Mountains and the Coon Creek Project area and adjacent subwatersheds in the Encampment River drainage of the Sierra Madre Mountains.

Experiments to determine forest water balance, forest stand-level physiology, and effect of timber harvest on water yield in subalpine forests are done on the Fool Creek watershed on the Fraser Experimental Forest near Winter Park, Colorado, and in the Coon Creek Project in the southeastern Sierra Madre Mountains of the MBNF.

Water for irrigation and urban water supplies comes from the mountains of the MBNF. In the past half century snow catchment, water flow manipulation by tree harvest, and trans-mountain diversion have all been used to augment water supplies originating on the MBNF. The southern Medicine Bow Mountains, Sherman Mountains and Laramie Mountains are all rather dry mountain ranges

surrounded by semi-arid basins and plains. The areas with substantial winter snow accumulations are high elevations around Medicine Bow Peak and most of the southern Sierra Madre Mountains.

A hydrologic budget for a Wyoming lodgepole pine forest receiving about 24 inches (66 cm) of annual precipitation is shown in Figure 6.24. Leaf area (expressed as Leaf Area Index - LAI) is a critical factor in the hydrologic budget of a forest. Mature forests, or forests with a lot of leaves, have a high (LAI) and transpire more water back into the atmosphere than areas with low LAI (meadows, young forests, thinned forests). The transpired water is not available for stream flow. On the average, 35 percent of the annual precipitation is transpired and 65 percent reaches the stream via surface or subsurface flow in lodgepole pine forests in the Medicine Bow Mountains. However, the actual amount reaching streams is quite variable, ranging from 33-95 percent (Knight, 1994).

Hydrologic and climatic measurements were taken on Fool Creek and the control area (St. Louis Creek) for 11 years prior to harvest in 1954-56. Forty percent of the watershed was clearcut in alternating strips of various sizes. Projected effects of the treatment will last 80 years, until the original LAI is attained. Peak snowpack water equivalent initially increased by nine percent on Fool Creek. Streamflow increased an average of 3.2 inches for the first 28 years after harvest, but has decreased since the mid-1980s about 0.04 inches per year. The increased water results mainly from decreased evapotranspiration and changes in timing and rate of snowmelt. There is less evapotranspiration from surfaces of snowpack than from snow on tree branches (Wilcox personal communication). Summer precipitation does not appear to contribute to water yield regardless of presence or absence of vegetation (Troendle and Kaufmann 1987).

In 1969 timber harvest in the upper Encampment River drainage in Colorado and Wyoming was planned, and the Encampment River Barometer Watershed Program was established on the MBNF to evaluate the impact of timber harvest on stream habitat in selected areas. Pre-harvest data was collected between 1969 and 1971. Eight streamside stations were established for monitoring fish and macroinvertebrates (Oberholtzer 1972). The timber harvest program did not go as planned and the Regional Office of the Forest Service abandoned the Encampment River Barometer Watershed program in the late 1970s (Oberholzer 1980). In 1980 Region 2 proposed the Coon Creek Project for the same area, in response to a Washington Office Initiative for augmentation of water supplies from National Forest Lands (Bevenger and Troendle 1987). The Coon Creek Project in the Sierra Madre Mountains is a major research effort involving paired watersheds to measure the effects of timber harvest on streamflow and habitat using a pattern of small, dispersed clearcuts.

The Fraser Experiments and Coon Creek Project were preceded by many smaller scale studies on how management could increase water yield in forests and lively debates on the merits of removing vegetation from watersheds to increase water yield. In 1928 Carlos Bates and T. Henry published the classic forest water balance study from Wagon Wheel Gap on the Rio Grande. On the heels of that study was a movement to increase western water supplies by severe cutting. Bates (1932) fiercely defended the important function of forest cover in protecting soil resources and tempering runoff. His comment in a letter to the American Society of Civil Engineers:

> Has the time arrived when Man may assume the audacity to start reversing these great constructive processes of Nature, for the sake of a temporary benefit, to water a few paltry additional acres of crops or to permit a few more poeple to congregate in the cities? The Engineering Profession is not lacking in audacity, and it frequently defaces and defiles Nature for the sake of a temporary gain. When such a proposal as that of Messrs. Hoyt and Troxell is being seriously put forward, it is time for the profession to ask itself whether or not is is truly giving heed to the interests of humanity (Bates 1932).

Between 1940 and 1948 a number of papers were published from experiments on the Fraser Experimental forest on increasing water yield by clearcutting young lodgepole pine and aspen. Experiments in young lodgepole pine stands (ca 20-30 years old) indicated that a maximum number of shaded, sheltered openings in young stands would produce optimum conditions for storage and prolonged melting of snow (Neiderhof and Dunford 1942). Aspen and grass were found to be superior to dense coniferous forests for supply of water to streams (Dunford and Neiderhof 1944).

Later studies concentrated on older lodgepole pine forests. During World War II, Dunford (1944) published results of water yield increases from cuttings at four intensities varying from removal of about half of the orginal stand, to an overstory removal that left only trees less than ten inches in diameter. He concluded that removal of all merchantable trees larger than ten inches in diameter increased water availablity by 31 percent. Additional experiments involving selective cutting of lodgepole pine stands, removing merchantable trees larger than 9.5 inches DBH resulted in a similar increase in water availablity, but did not cause erosion, did not disrupt the litter of the forest floor, and did result in aspen and lodgepole pine regeneration.

After World War II clearcutting became widspread, and growing cities were seeking augmented water from the Rocky Mountains. Ways to increase water yield through snow entrampment associated with clearcutting were researched. Several studies in the 1960s indicated that there were no actual differences in total

snow accumulation from clearcuts. Effects of small patch clearcutting were investigated by Gary (1974, 1980) in experimental openings created in lodgepole pine forests on the MBNF near Foxpark, Wyoming, partly to solve the debate of whether or not additional snowpack really accumulated in openings, or whether the snow accumlated in openings was merely redistributed from forest on the lee side of the opening. If redistribution was true, then effects of augmented streamflow were really due to a difference in timing of snowmelt rather than more snow being trapped (Figure 6.25).

Gary concluded that small clearings did not affect the total amount of snow "caught" in the area, but did affect the snow distribution pattern. The important point is that the results of this and other studies suggested that up to 50 percent of a watershed could be placed in small clearcut patches without adversely affectng snow accumulation and redistribution. Hoover (1969) and Alexander (1974) suggested that up to one half of a watershed could be placed in small dispersed openings which could be maintained indefinitely or regenerated to new forests and the cycle repeated on uncut forest. The dispersed opening approach is being tested at Coon Creek, which was harvested in the late 1980s-early 1990s. Watershed management in the subalpine zone was reviewed by Leaf (1975). Recent research has indicated that the highest water yields come from partial cut areas (Wilcox, Troendle personal communication).

In addition to the manipulation of forest cover and stand structure to increase water yield, there was discussion the mid-1970s to increase snowfall by cloud seeding. The Medicine Bow Ecology Project (1975) was a series of studies on the potential impacts of augmented snowpack on many components of biological diversity on the Medicine Bow National Forest (Knight et al. 1975). These studies included impacts of snow on elk, mule deer, meadows, forest understory species, litter decomposition, nutrient leaching, birds, mammals, and vegetation biomass production and the effects of silver iodide and increased runoff on aquatic ecosytems. The cloud seeding was never implemented.

Similar studies occurred during the same time period in southern Colorado (Dix and Richards 1976). Many speculations about ecosystem behavior, based on responses of individual species to increased snowpack and shorter growing seasons emerged from these studies. "Costs" and "benefits" to ecosystems were qualitativley assessed for some studies. Many results were inconclusive or the studies were of too short duration to separate effects of cloud seeding from background ecosystem variation.

NUTRIENT CYCLING AND OTHER PROCESSES

Studies of canopy interception of precipitation and throughfall and litter interception of precipitation are stand-level processes that relate to overall forest

hydrology. The effect these processes have on various aspects of biological diversity are not well known. Research on the MBNF concerning forest processes affecting biological diversity in subalpine forests can be found in Fahey 1983, Knight et al 1985, Fahey et al. 1985, Knight et al. 1991, and Knight 1994.

Lodgepole pine forests of the MBNF near Foxpark have been used for studies of nutrient cycling, especailly nitrogen, by Dennis Knight, Department of Botany at the University of Wyoming, and several graduate students. Studies on uncut and thinned forests were done to determine storage and movement of nitrogen, phosphorus, calcium, magnesium, and potassium in above-ground detritus including leaf litter and tree boles.

Decaying tree boles are an important source of nitrogen immobilization in lodgepole pine systems, especially 50 years or more after tree death as bacteria and fungi cause decay (Fahey 1983). Nutrient-enriched decaying logs may be important for site productivity as well as for biological diversity (Knight 1994). More recently water and nitrogen outflow from a clearcut stand, a thinned stand, and an uncut stand were measured. Clearcutting increased nitrate concentrations 10-40 times above the uncut and thinned stands and increased nitrogen outflow by about 37X. Thinning of stands hardly increased nitrogen outflow. Most nitrogen loss occurs after disturbance through leaching during the three to six week spring snowmelt period (Knight 1994).

Specific temporal effects of nutrient cycling on biological diversity are not well understood. Many interactions with bacteria, fungi, lichens, forbs, grasses and woody plants exist. It can be surmised however, that since nitrogen is a major limiting nutrient in Rocky Mountain coniferous forests, loss of this nutrient from ecosystems may cause ecosystem simplifications including reduced species diversity. The full spectrum of possible effects on forest processes is unknown.

DISTURBANCES OTHER THAN FIRE

Disturbance can assume many forms and act at many scales. It may be mechanical damage or parasitic infection at the level of the individual organism affecting growth rate, reproductive ability, or competitive advantages or causing death. For prey, predators are agents of disturbance; for plants, herbivores are agents of disturbance. Disturbance may act on many organisms of many species over continuous or discontinuous areas. Disturbance also affects the flow of materials and energy in ecosystems.

Good or bad values are often assigned to kinds of disturbance by humans. Frequently, an event which is a "bad" disturbance (i.e. damages the life of an individual or group of organisms), is a "good" disturbance for others. There are

often conflicts between values associated with disturbance-causing activities initiated by management (e.g. forest stand age diversification, dwarf mistletoe or insect infestation eradication) which have legal justification in Forest Plans but have differential values to various ecosystem components or individual species.

Effects of disturbance are strongly tied to both spatial and temporal scales. Removal of an old forest for a 400 year period while a new one grows is insignificant in the scale of Post-Pleistocene time (1000s of years), but may be highly important for viability of a species whose persistence depends on ecosystem supports from year-to-year. A disturbance may seem temporary in a long time frame (such as several hundred years for forest regrowth), but may have more permanent effects depending on cumulative effects and intervening events. The area and pattern affected by single or multiple disturbances over time is also important.

BLOWDOWN

Blowdown can be facilitated by fire, insect infestation, and various fungal infections. Problems with blowdown associated with clearcut spruce-fir forests were encountered between 1950 and the mid-1960s in Region 2. This prompted reports on the condition of spruce-fir cutover areas and minimizing windfall around clear-cuttings in spruce-fir forests (Averill 1964; Alexander 1964). Site analysis for windfall in spruce-fir for 15 sites cut between 1950 and 1957 included five sites on the Routt National Forest and two on the Arapaho-Roosevelt. The cutting patterns included vertical strips 150-200 feet wide, contour strips 200-400 feet wide, and clearcut patches three to 129 acres in area. Eleven specific recommendations to consider in timber sale site planning to minimize windfall were presented (Alexander 1964).

Strong winds are common in the MBNF and blowdowns are known in several locations in the Sierra Madre and Medicine Bow Mountains. Blowdowns associated with clearcutting on the MBNF were especially problematic in block cuts of the 1970s in the northern Snowy Range.

TIMBER HARVEST

Timber harvest is a man-caused agent of disturbance which can alter stand age structure both within stands and among stands at a landscape level, creating new patterns within a forested matrix and in relation to natural openings. This benefits some organisms while destroying or damaging others. Clearcut timber harvest has no exact analog in nature. Similarities between clearcutting and catastrophic fires have mostly to do with landscape pattern changes, the effects of which are not well understood despite years of study.

Beyond pattern changes, there may be more differences than similarities between clearcutting and catastrophic fires. Catastrophic fires do not remove tree bole biomass as does clearcut timber harvest; fires often leave a hydrophobic coating on the soil and remaining organic matter. Fire-adapted species resprout quickly after a fire, but may be removed or severely damaged by post-harvest treatment. Seeding of native or non-native grasses, commonly done as post-havest treatments would not happen "naturally" after fire. There are no natural soil disturbance analogs to rollerchopping. Effects of both fires and timber harvest on nutrient cycling are largely unknown.

Partial cut harvest (individual tree selection, two- to three-step shelterwoods, group selection) have some similarities to canopy gap formation for patch size of disturbance, but there are also many differences including the selection of species and individuals by man, the removal of biomass, the construction of roads, and soil compaction which often accompanies modern harvest methods.

CLEARCUTTING AND PARTIAL CUTTING

History of Timber Harvest Methods

The first Research Paper from the Rocky Mountain Station in Fort Collins was entitled *Alternate Clear Strip Cutting in the Lodgpole Pine Type* (Lexen 1949). Lexen recognized that virgin lodgepole pine was often broad-aged (100-250 years old), rather than even-aged. He argued that because of its aggressive reproduction characteristics on disturbed areas, it was a species well adapted to even-aged management, unlike many of the European pines which did not reproduce well with strip clearcuts.

With the warning that it was not the complete answer to management of the species, Lexen outlined conditions for which alternate clear strip-cutting was suitable for lodgepole pine,:

1. Reduction of after-cutting fire hazard in even-aged stands
2. Retardation of spruce-fir climax
3. Regeneration of poor sites
4. Protection of residual stands after heavy thinning

Conditions for which alternate strip-cutting was unsuitable were identified as:

1. Overmature insect-infested stands
2. Mistletoe-infected stands
3. Stands with aspen understory (if lodgepole is the desired regeneration type)
4. Stands of mixed patches of age classes

Other recommendations included keeping strip width less than 180 feet on south exposures, placing strips perpendicular to drainages, and cutting leave strips lightly. Three systems of silvicultural treatments were recommended (Figure 6.26).

In 1973, Carl Berntsen, Assistant Director of RMFRES in Fort Collins, discussed management conflicts in lodgepole pine:

> Until recently, there has been an unshakable attitude among foresters managing lodgepole pine stands that clearcutting is the only silvicultural system applicable for management of this species. Although attitudes have changed somewhat in the last year or two, there has been an almost negligible account of on-the-ground application of alternative silvicultural systems. In large measure, the reluctance to substitute some other system for clearcutting is economic. This is understandable because lodgepole pine is a generally low value, low volume timber species. However, perhaps as important as economics is the general lack of knowledge about the ecological requirements of the species and the amplitude of timber stand manipulation it can tolerate (Berntsen, 1973).

Debate on alternative harvest methods for lodgepole pine forests continues into the present. Clearcutting is still the dominant harvest method.

Recommendations for how to harvest both lodgepole pine and spruce-fir in the Rocky Mountains continued to come from the Rocky Mountain Forest and Range Experiment Station in Fort Collins after Lexen's 1949 paper. Robert Alexander and several associates produced most of the Station publications between 1954 and the late 1980s (Tables 6.5 and 6.6).

Methods of integrating timber management and water yield efforts evolved over the past half century. Most silvicultural studies from the 1930s to 1960s were concerned mainly with increasing growth rates in trees and maximizing water yield. Research emphasis in the Central Rockies was on lodgepole pine. By the 1960s there was a large literature on cutting old growth lodgepole pine as well as old growth spruce-fir, and concern about the effects of such practices on other values (Figure 6.27) including wildlife habitat, recreation, and aesthetics. Today, broader concerns of effects of timber harvest would include effects on biological diversity, landscape pattern, function, and sustainablity. These and other concerns are currently important issues in planning and management.

Table 6.5 **Selected publications containing recommended timber harvest methods for lodgepole pine 1954-1988.**

Alexander, R.R. 1956. Two methods of thinning young lodgepole pine in the Central Rocky Mountains. Journal of Forestry 54(2):99-102

Alexander, R.R. 1960. Thinning lodgepole pine in the Central Rocky Mountains. Journal of Forestry 58(2):99-104

Alexander, R.R. Growth of thinned young lodgepole pine in Colorado. 1965. Journal of Forestry 63:(6):429-433

Alexander, R.R. 1966. Harvest cutting old-growth lodgepole pine in the Central Rocky Mountains. Journal of Forestry 64:113-116

Alexander, R.R. 1975. Partial cutting in old-growth lodgepole pine. USDA Forest Service Research Paper RM-136

Alexander, R.R.; Edminster, C.B. 1980. Lodgepole pine management in the Central Rocky Mountains. Journal of Forestry 78:198-201

Schmidt, W.C.; Alexander, R.R. 1985. Strategies for managing lodgepole pine. pp. 201-210 IN: Lodgepole pine, the species and its management. Washington State University Cooperative Extension Pullman, WA

Baumgartner, D.M.; Krebill,, R.G.; Arnott, J.T.; Weetman, G.F. 1985. Lodgepole pine: The species and its management. Symposium Proceedings May, 1984. Spokane WA and Vancouver, B.C. Canada. Washington State University, Pullman, WA

Table 6.6 Sequence of publications containing recommended timber harvest methods for spruce-fir 1954-1988.

Alexander, R.R. 1963. Harvest cutting old growth mountain spruce-fir in Colorado. Journal of Forestry 61(2):115-119

Alexander, R.R. 1964. Minimizing windfall around clear-cutting in spruce-fir forests. Forest Science 10(2):130-142

Noble, D.L.; Alexander, R.R. 1977. Environmental factors affecting natural regeneration of Engelmann Spruce in the Central Rocky Mountains. Forest Science:23(4):420-429

Alexander, R.R.; Edminster, C.B. 1977. Uneven-aged management of old growth spruce-fir forests: Cutting methods and stand structure goal for the initial entry. USDA Forest Service Research Paper RM-186. Fort Collins, CO

Alexander R.R. 1977. Cutting methods in relation to resource use in Central Rocky Mountain spruce-fir forests. Journal of Forestry 75:395-400.

Alexander, R.R., Edminster, C.B. 1977. Management of spruce-fir in even-aged stands in the Central Rocky Mountains. Research Paper RM-217 Fort Collins, CO.

Alexander, R.R. 1984. Natural regeneration of Engelmann spruce after clearcutting in the Central Rocky Mountains in relation to environmental factors. USDA Forest Service Research Paper RM-254. Fort Collins, CO.

Alexander, R.R. 1987. Ecology, silviculture and management of the Engelmann spruce-subalpine fir type in the Central and Southern Rocky Mountains. USDA Handbook 659. Fort Collins, CO

Troendle, C.A.; Kaufmann, M.R.; Hamre, R.H.; Winokur, R.P. 1987. Management of subalpine forests: Building of 50 Years of Research. Proceedings of a Technical Conference Silver Creek, CO. July 6-9, 1978. USDA Forest Service General Technical Report RM-149. Fort Collins, CO.

Clearcutting of spruce-fir forest was used as a tool to reduce insect infestations throughout Region 2. Spruce harvest increased when Regions 1 and 2 put over a half-billion board feet on the market in connection with bark beetle control programs of 1954-1957. Many areas cut during this period (1955-1964) regenerated poorly, particularly those cut 1960-1964. Increased use of tractor-logging and more intensive slash treatment were cited as contributing factors (Averill 1964). In 1964 Averill estimated 2,163,000 acres of spruce-fir forest (sawtimber) was available in Colorado, compared to 318,000 in Wyoming. Although about ten percent of the Colorado acreage was insect-killed and little to none was insect-killed in Wyoming, the high elevation spruce-fir forests of the MBNF were cut heavily during this time.

In the Medicine Bow Mountains, lodgepole pine clearcutting has been ubiquituous and widespread in many age classes below about 9500 feet since 1950. Strip and block cutting of high elevation spruce-fir stands occurred from 1955 to about 1980, mostly in high-volume stands with origin dates from the late 1600s to about 1850. This converted old forest, which was largely a continuous closed canopy matrix, to a forest matrix perforated by young forest patches.

Regeneration

Regeneration in lodgepole pine at lower elevations on the MBNF has never been a problem. It usually regenerates so prolifically that it must be thinned. In 1909, Carlos Bates, with the cooperation of Forest Supervisor Hubert Hilton, conducted experiments to determine how to silviculturally control the prolific reproduction in lodgepole pine so that expensive artifical thinning would not be needed (Bates et al. 1909).

Regeneration in high elevation spruce-fir forests is inconsistent even under partial cutting schemes and becomes a greater problem in clearcuts (Ronco 1970; Noble and Alexander 1977). Factors affecting regeneration of Engelmann spruce at Fraser Experimental were identified between 1968 and 1972 (Noble 1974; Alexander 1977) (Figure 6.28). Comparison of the favorable/unfavorable conditions with conditions at specific high-elevation clearcut sites in the Medicine Bow Mountains suggests why regeneration is slow and spotty in many areas. The Medicine Bow Mountains have climatic limitations, sheep grazing, heavy-textured soils, sod-forming sedges in mesic/hydric areas, nearby populations of birds and rodents resident in uncut forests and meadows, and late-lying snowfields with conditions favorable for snowmolds.

Although most clearcut sites are certified for regeneration, regeneration of spruce-fir or late seral mixed conifer forests has been a concern on the MBNF. Notable regeneration problems occurred in the high elevation ($\sim$10,000 feet) clearcuts near the top of north-facing slopes of French Creek Canyon (early 1970s) and in

block clearcuts in the Rock Creek watershed during the mid-1970s. Both types of sites are very harsh and subject to strong winds.

Until about 1950, timber harvest on the MBNF was primarily by selective cutting of lodgepole pine or mixed conifer stands in accessible locations at lower to mid-elevations. The forest product market for the Medicine Bow National Forest prior to World War II was mainly mine props and railroad ties. Clearcutting became a domimant method of timber harvest applied to all forest types after World War II with the advent of larger mechanized harvesting equipment, road development at higher elevation and less accessible areas, and increased markets for sawtimber.

Timber harvest activites on the MBNF can be summarized as follows:

1. Very little timber harvest occurred in the Laramie Mountains prior to about 1988 when thinning and salvage logging was practiced in the Albany Peak, Black Mountain, Laramie Peak, and Friend Park areas, mainly in ponderosa pine.

2. No significant timber harvest has occurred in the Sherman Mountains since the 1950s. Forests have been regenerating since the cut and burns of the 1860s.

3. Clearcutting in the Sierra Madre Mountains was mainly east of Blackhall Mountain in the 1950s, but became widespread in the 1960s-1980s. The Coon Creek Project consititutes most of the clearcutting since 1990.

4. A lot of high-elevation clearcuts were made in the 1950s and 1960s in the Medicine Bow Mountains, especially strip cuts in the Brush Creek and Medicine Bow River Watersheds of the Brush Creek District. The large block clearcuts in the Rock Creek Drainage were done in the 1970s. Partial cutting of both leave strips and forest matrix areas is widespread in both the Medicine Bow and Sierra Madre Mountains.

TIMBER HARVEST AND BIOLOGICAL DIVERSITY

Aspects of the relationship of timber harvest to biological diversity are discussed in this section of the report. These are:

1. wildlife habitat

2. partial cuts and clearcuts and underlying forest stand age

3. age fragmentation of forested landscapes

4. landscape measurements of clearcut and partial cut patterns.

5. vascular plant biological diversity and succession in clearcuts

6. effects of timber harvest on lichen biological diversity

WILDLIFE HABITAT

Thomas et al. (1975) provides an excellent discussion of silvicultural options for habitat values in coniferous forests using habitat requirements for guilds of bird species. Detailed discussion of species-habitat relationships for Rocky Mountain forests is in *Managing Forested Lands For Wildlife*, developed cooperatively between the Forest Service (Rocky Mountain Region) and the Colorado Division of Wildife (Hoover and Wills 1987). Thomas (1979) and Thomas and Maser (1986) have detailed information on species-habitat relationships for vertebrates of rangelands and forests. Most species described in these reports are found in similar habitats on the Medicine Bow National Forest.

With regard to our knowledge of subalpine habitat management for spruce-fir forests, Jack Ward Thomas expressed the following concern in a 1987 Symposium on spruce-fir forest management at Silver Creek, Colorado.

> There is much less research done on wildlife habitat relationships in these forests than in lower elevation forests. This relative paucity of information on wildlife habitats in subalpine areas - particularly as it relates to management manipulation of forests - should raise a flag of caution to managers. This flag of caution should be magnified in effect when it is considered that subalpine ecosystems in general (not just in terms of wildlife habitat) are relatively poorly understood. It is obvious, however, that subalpine ecosystems are relatively fragile - the last transition from forests to the non-forested alpine zones. Such forests exist on relatively thin and poorly developed soils of low fertility, and endure severe climates and short growing seasons. Subalpine forests are much less forgiving of a manager's mistakes than the lower elevation forests that have provided most of our experience with forest and wildlife management ... managers need to heed the whisper in their ears that warns that knowledge is not adequate to predict with confidence, over the long term, the effects of forest manipulation on most resident wildlife (Thomas 1987).

Increase in edge from cutover areas often promotes an increase in populations of large ungulates such as deer and elk, as well as birds which utilize habitat edge (Franklin 1993; Keller and Anderson 1992). Timber harvest and other

disturbances which suddenly alter closed-canopy forested habitat will favor disturbance-adapted plant and animal species but often eliminate or reduce populations of species needing interior forest habitat. Large amounts of edge habitat have been created by clearcut timber harvest on the MBNF in the past 50 years.

Relevant studies on wildlife habitat relationships have been done either on the MBNF, the Fraser Experimental Forest, or other Rocky Mountain conifer or aspen forests (Appendix 1). Further review and summarization of wildlife habitat relationships to landscape structure is needed. Additional information on wildlife species is in Chapter 8 of this report.

In 1980, Bill Blunt, wildlife biologist on the Medicine Bow National Forest, prepared a matrix of relationships among wildlife habitats and successional stages of lodgepole pine forests. This useful compilation included habitat compositional and structural information for succesional stages and related that to feeding and reproduction requirements for specific bird and animal species (Blunt 1980). It did not include an inventory of what was available on the forest for each species. Amount of available habitat on the MBNF is not well known despite modeling efforts such as HABCAP (Habitat Capability Modeling - USFS).

Wildlife habitat-timber harvest studies on the Fraser Experimental Forest include Scott et al. (1982). With regard to big game, studies showed that after an initial negative response to clearcutting, deer use of clearcuts increased for about 15 years and was projected to last beyond 20 years. Although clearcuts increased the availablity of forage during the spring, summer, and fall, the limiting factor to the capability of subalpine forests for support of increased herds is the limitation of winter range (Crouch 1987). On the MBNF many studies have been the subject of research on the effects of timber harvest on big game (Wallmo 1969; Regelin and Wallmo 1978; Crouch 1987).

Wildlife habitat research is associated with the Coon Creek project, especially for birds and small mammals (Raphael 1987,1988; Brown 1994) (see Appendix 1 for additional studies). There are few conclusive results as yet from the Coon Creek studies of effects of clearcutting on small mammals and birds since these studies have been in progress less than a decade.

Management of nongame birds of the the Rocky Mountain spruce-fir forests was reviewed by Smith (1980). Scott and Crouch (1988) found that small inclusion of aspen in conifer forests were too small to provide habitat for aspen obligates. Finch and Reynolds (1987) evaluated bird response to understory variation and conifer succession in aspen forests in plots on the Routt and MBNF. Habitat relationships for various seral stages of lodgepole pine with regard to bird species was done by Austin and Perry (1979) in the Uinta Mountains of eastern Utah.

Orde (1993) provides a current literature review on the effects of human-induced forest fragmentation on birds. Silvicultural effects on birds of the Rocky Mountains are treated by Finch and Fletcher (1994). This paper includes an assessment of the relationships of neotropical migratory birds to clear cut and partially cut forests from zero to 40 years of age. There are many studies of birds and timber harvest on the MBNF during the past 15 years.

Ruggiero and Gluesing (1981) discuss the integration of ecological diversity requirements for wildlife habitat into forest management and planning. Numerous studies (Ward, Haas, Butler, and others) have been done on effects of timber harvest and big game on the Medicine Bow National Forest. Old growth forests as wildlife habitat are discussed by Meslow et al. (1981). (See Appendix 1).

The papers cited in this section are a small percentage of the available literature on wildlife-habitat relationships. Additional analysis is needed to summarize what is known and apply it to managing specific landscapes.

STAND AGE AND STAND STRUCTURE

Stand age and structural stage data are available for areas outside Wilderness (except for the Platte Ridge Wilderness Area) from Stage II Timber Inventory for the Sierra Madre and Medicine Bow Ranges. For this analysis, stand ages are divided into six groups (Figure 6.29). Stand origin dates are not changed in the RIS database for partial cuts until the end of the first rotation of two- to three-step shelterwood cuts. Thus, Figure 6.29, which shows stand ages for all stands, does not discriminate among partial cut and uncut areas. See Figure 6.31 for this detail.

Presumably most of the forests from the 1850-1900 period originated after widespread stand-destroying fires characteristic of this historical period. In the Sierra Madre mountains there is very little forest with stand age over 145 years. There is more forest in the 1850-1910 stand origin group than in all other age classes (Figure 6.30). Acres of forest older than 1850 (old forest) are approximately equal to acres of young forest (younger than 45 years - originating since 1950). If acreage for partial cuts is subtracted from the >1850 category in Figure 6.30, then there is more young forest than old forest in the Sierra Madre mountains.

Old forests exist in high elevations of the northern Snowy Range. There is about 30 percent more acreage in old forest than in young forest in the Medicine Bow Mountains (Figure 6.30). For both mountain ranges, there is the most acreage in forests originating 1850-1910, and the least in forests originating 1911-1949. Tables of stand age acreage by cover type and watersheds are in Appendix 12.

Structural stage characteristics of MBNF forests are presented in Figure 6.31. Note that structural stage data are available for nearly all areas except most of Sheep Mountain and Savage Run, Huston Park and part of the Platte River Wilderness Areas. Compare the pattern of occurrence of complex structural stages in the Medicine Bow Mountains with forest age structure in Figure 6.29.

Most previously contiguous areas of old and/or structurally complex forests have been fragmented by clearcutting or altered by partial cutting. Complex structural stages are less common in the Sierra Madre Mountains. In the North Spring Creek area (BDU 14) structurally complex forests, old forests have been perforated by clearcut harvest. The same is true for the Medicine Bow Mountains for BDU 62 (South Rock Creek).

Vegetation disturbance from timber harvest, fire, and blowdown is shown in Figure 6.32. In this figure, forest age is coded from old to young by progressively lighter shades of green. Disturbance from various kinds of disturbance can be viewed in the context of age classes of adjacent stands.

Inspection of these figures shows that most forests older than 1849 are found mainly north and west of Medicine Bow Peak and north of Kennaday Peak in the Medicine Bow Mountains. Scattered, smaller patches occur in the southern Medicine Bow Mountains and along the eastern side in the upper elevations of the Laramie River Drainage. The small acreages of forest older than 1849 in the Sierra Madre Mountains occur near the Continental Divide in the the northern part of the Sierra Madre, on either side of the Encampment River Canyon, and south of the Coon Creek watershed, along the Colorado border.

Remaining patches of uncut pre-1850 forest stands, with a 60 meter depth of edge influence subtracted from patches, are shown in Figure 6.33. Edge includes natural edges (meadows or talus) as well as age-contrast edges caused by timber harvest which may be occupied by regenerating trees. In the context of a forest 150 years old or more, forest stands 45 years old or younger are categorically young forest.

In contrast to the few large patches of remaining old forest there are large areas of forest which originated between 1850 and 1910. This includes most of the forests of the Sierra Madre Mountains, the southern Medicine Bow Mountains and most forests at lower elevations in the northern Medicine Bow Mountains. Far less forested acreage, mainly around the edges of both mountain ranges and in the southern Medicine Bow Mountains, was regenerated from 1910-1949. Clearcutting since 1950 has regenerated substantial acreage.

Few relatively large patches of uncut forest originating before 1850 remain on the MBNF. The largest areas in the Medicine Bow Mountains are north of Kennaday

Peak in the upper Pass Creek and upper South Cedar Creek Watersheds, the upper south Rock Creek watershed, in the lower south Rock Creek and Fourmile Creek watersheds (the Threemile Timber Sale Analysis Area), and part of the upper Middle Fork of the Laramie River (Fall Creek Timber Sale Analysis Area).

In the Sierra Madre the only large areas of forest predating 1849 are in the upper Big Sandstone/Jack Creek Drainages (Strawberry Gulch, Deep Creek Timber Sale Analysis Area), south Spring Creek adjacent to State Land, and two areas in the Encampment River watershed - the East Fork of the Encampment River which is the control area for the Coon Creek project and the Damfino Creek watershed south of the Coon Creek Project area.

Oldest forest classes have been removed through widespread timber harvest since 1950 by both clearcutting and partial cutting. Fire/blowdown has affected old forest in the Kennaday Peak area and in South Brush Creek. Other fire/blowdown disturbance is in younger forest in the 1850-1910 age group. Acreage totals for disturbance to various age classes of forest cover types listed in Appendix 12 are summarized in Table 6.7.

AGE FRAGMENTATION OF FORESTED LANDSCAPES

Diversification of age structure in forests using clearcutting and partial cutting has been a management objective at least since the 1950s. It is incorporated into the timber harvest schedules and treatments of the 1985 Forest Plan. Forest patterns were addressed by the Report of the External Group Review of the Forest Plan Five Year Review (Medicine Bow National Forest, 1990). Forest patterns created by clearcutting, changes to pattern of old growth, and effects of timber harvest on wildlife habitat were addressed within the *Problem Area of Biodiversity* in Appendix B of the Five Year Review:

> The current dispersion/diversity guidelines may well over disperse the various structural types, creating undesireable forest fragmentation. The diversity created by this approach could far exceed natural diversity on the area.
>
> Similar concerns arise relative to old growth units which must occur in every area of five thousand to twenty thousand acres or in fourth order watersheds. These old growth units can be as small as thirty acres. The Forest should evaluate the fragmentation effects of this approach and pay more attention to old growth units of larger size with consideration given to travel corridors between old growth units. It should be kept in mind that the Forest

Table 6.7. **Disturbance acreage and forest age classes for lodgepole pine and spruce-fir forest. From Appendix 12. Source - RIS data base.**

Sierra Madre Mts.

Age category	Uncut	Partial Cut	Group ShWood	Clearcut	Fire Bldwn	Total
Older than 1850	21,488	2,116	0	0	0	23604
1850-1910	90,386	2,689	0	0	0	93075
1911-1949	8,863	485	0	0	0	9348
1950 or younger	2,218	4,418	0	14,631	303	21570
Total	122,955	9,708	0	14,631	303	147597

Medicine Bow Mts.

Age category	Uncut	Partial Cut	Group ShWood	Clearcut	Fire Bldwn	Total
Older than 1850	98,096	10,605	2,363	0	536	111593
1850-1910	179,075	6,227	780	0	161	186243
1911-1949	21,696	2,840	48	334	213	25131
1950 or younger	7,116	5,944	1,120	53,913	4209	72302
Total	305,983	25,459	4,311	54,247	5119	395269

Summary	Sierra Madre Mts	Medicine Bow Mts.
Uncut forest older than 1850	15%	25%
Partial cut forest older than 1850	1%	3%
Uncut forest 1850-1910	63%	45%
Partial cut forest 1850-1910	7%	7%
Total clearcut since 1950	10%	14%
Total partial cut since 1950	7%	6%

> direction dictating diversity goals is written specifically for the management of fish and wildlife habitats and should primarily reflect those interests (Medicine Bow National Forest, 1990 Appendix B page 8).

As a follow-up to this concern expressed in the Five-Year Review, analysis of forest pattern and old growth, done in 1993-94, is presented in this chapter and in Chapter 9.

Numerous studies have documented adverse effects of forest fragmentation on populations of species which prefer or need large areas of mature forest (Harris 1984; Wilcove 1987; Grumbine 1990; Saunders et al. 1991). Fragmentation can be short-term (a few years to a century) such as age fragmentation or other alterations which do not prevent succession, or long term (many centuries) where succession is either very slow (as for high elevation forests) or prevented (urbanization or agriculture). For persistence of populations of plants or animals, habitat fragmentation for even a few years can mean extirpation from a local or larger area.

Fragmentation can isolate populations of organisms with limited mobility, changing gene flow among remaining populations and disrupting genetic clines. Fragmentation of existing structural continuity of mature forests by timber harvest can be expressed as changes in patch size (where patches have definable characteristics of species composition, age, and structure) and change in edge (where edge can be along a gradient from very high contrast to gradually declining differences). All of these affect the biological basis for evolution and adaptation of organisms and ecosystems.

Decline in patch size of mature forest can make a landscape more vulnerable to catastrophic events such as blowdown which amplifies fragmentation and isolation of remaining mature forest patches (Franklin 1993). Smaller populations of animal species are more vulnerable to extinction in any particular patch due to:

1. increased vulnerablity to natural disasters
2. chance effects of disasters on populations
3. genetic deterioration
4. social dysfunction

Increased edge within an old forest matrix and distances between patches of old forest are generally considered to be detrimental to native biodiversity and to have negative effects on population viablity of species preferring old forest habitats (Yahner 1988; Reese and Ratti 1988). A study in the Black Hills (Crompton 1994) found that "only in untreated patches larger than 1000 hectares (2470 acres or nearly four square miles) was the full complement of interior forest birds

present." Studies of these effects on specific species are few, but increasing. With the exception of limited work on several bird species and pine marten, there has not been study of the effects of fragmentation and edge on the Medicine Bow National Forest.

LANDSCAPE MEASUREMENTS

Pattern Analysis

Pilot studies investigating the feasiblity of analyzing GIS information from the RIS database of the MBNF were begun in 1993. The quality and completeness of the RIS data on the MBNF and the extensive Stage II inventory data over most of the Medicine Bow and Sierra Madre Mountains made this analysis possible.

Prior to the availablity of GIS information in the Resource Information Database (RIS), was recorded on mylar maps at 1:24,000, requiring hand-coding. Map attributes were in a mainframe database system which was awkward and difficult to use. Arc-Info GIS now can summarize this information into maps and tables. Maps and tables in this report come from this source. Geographic information system technology (GIS) enables detailed analysis of landscape-scale disturbance patterns created by timber harvest, fire, and blowdown. It also enables description and analysis of landscape structure for understanding broad-scale biological diversity in relationship to existing patterns. Information from the succession in clearcuts study (Appendix 16) adds detail at the community level.

Despite its power of map-making, Arc-Info GIS has limited capablities for map analysis and measurement of landscape characteristics and patterns. To thoroughly evaluate landscape structure a contract was arranged with Dr. William Baker, Department of Geography, University of Wyoming to analyze existing landscape structure and old growth as portrayed by information in the RIS database. The final report, entitled *Landscape Structure Measurements for Watersheds in the Medicine Bow National Forest Using GIS Analysis*, was submitted in December, 1994. (Contract # UW5-35346). The r.le landscape metrics analysis program used for the study (Baker and Cai 1992) is in widespread use internationally.

The landscape analysis was structured as follows:

Analysis Units

1. Watersheds (BDUs were used as the smallest analysis units)

2. RIS Data were coded by:
   - cover type (18 broad classes)
   - five forest age classes

- 1) older than 1799
- 2) 1800-1949
- 3) 1850-1910
- 4) 1910-1949
- 5) 1950 and younger

- type of timber harvest
  - 1) clearcut
  - 2) group selection
  - 3) other types of partial cuts

3. Riparian areas were defined using a map overlay developed from the 1992-93 Riparian Inventory (contract) and coded for cover type from underlying RIS polygons. Riparian areas which were lines or points were buffered in order to have width which could be coded to a cover type.

4. Old growth forest was defined using three criteria: forests with stand age older than 1800 plus forests with structural stages 4 a,b,c or 5, plus forests with Old Growth Scores greater than 38. Use of multiple criteria is believed to give a more precise estimate of available old growth forest than any one of the criteria alone. Interior area of old forest (older than 1850) and old growth forest (as defined above) was estimated using edge effects from clearcuts and natural openings of 60, 120, and 180 meters. Fragmentation estmates are conservative because edge effects from roads could not be included in the analysis because the GIS road layer was not available.

Analysis procedures:

Cover Type only

1. Cover types among watersheds were analyzed to determine major characteristics of landscape pattern and variation. Principal Components Analysis was used on cover type and polygon size to determine similarities and differences.

2. Six Reference Areas (Figure 6.35) were chosen from unharvested roadless areas to use for comparative landscape measurements.

3. Each watershed was matched with a Reference Area most similar to its cover type characteristics.

Cover Type and age

4. Major characteristics of age classes of forested cover types were determined using Principal Components Analysis.

5. Effects of timber harvest, fire and blowdown on landscape pattern in forests of each watershed were assessed using a combination of the cover type and age class data.

6. Patterns of patch size for cover types of different age classes in watersheds were compared to patterns in Reference Areas which represented the best available examples of older, uncut forest of both lodgepole pine and spruce-fir cover types. Mean patch size, forest age characteristics, amount of edge, and other quantifiable landscape characteristics were used to determine which watersheds appeared to be least similar or most similar to the Reference Areas. This is a way to determine which areas are likely to be farthest from the mean landscape measurement values within a "range of natural variablity."

7. Analysis of distribution of old growth forest, patch size, and interior forest area was also done. This is discussed in Chapter 9.

Statistical Procedure

A commonly used multivariate statistical analysis technique called Principal Components Analysis (PCA) was used to find the main characteristics of the MBNF among the many data characteristics.

One level of analysis was done by cover type only; a second level added forest age to cover type. In the second level 54 landscape characteristics (indices) were defined by cover type, stand age, patch size, and number of patches. The 54 indices were condensed statistically to 35 Principal Components which describe main features of the MBNF landscape with regard to cover type and age.

Each Principal Component can be associated with one of the original 54 characteristics which is then used to describe that particular Principal Component. Variation in landscape structure is expressed as a percentage for a Principal Component. For example the per cent cover of lodgepole pine forests originating between 1910 and 1949 accounts for only about 2 percent of the variation in landscape structure among watersheds, while the Principal Component representing the map density of any patch less than 250 acres accounts for about 10 percent of the variation in landscape structure.

Of the 35 Principal Components found from analysis of both cover type and stand age, 25 of these were related to characteristics of forested ecosystems and 10 were related to non-forested systems (for example average patch size of riparian grassland patches). (See Table 15 of Baker 1994).

The 25 Principal Components associated with upland forested cover types formed five groups of patch types. These are are listed below by order of how much their pattern dominates landscape structure.

1. Forested timber management patches (~25% of the variation)

2. Forested patches with characteristics of both old forest and timber management (i.e. small clearcuts perforating old forest matrices) (~20% of the variation)

3. Non-forested patches (~21% percent of the variation)

4. Forest patches aged 1850-1909 (~16% of the variation)

5. Old forest patches (~16% of the variation)

Among the five groups, Principal Components were associated with major characteristics of forested areas (groups 1, 2, 4 and 5 listed above) and the amount of variation they individually represented were:

1.	Density of any patch with an average interior area less than 250 acres	(~10%)
2.	Average interior size of large patches	(~10%)
3.	Percent cover of aspen, 1850-1909	(~6 %)
4.	Density of post-1950 spruce-fir patches	(~6 %)
5.	Average interior area of spruce-fir, pre-1850	(~3 %)
6.	Percent cover of lodgepole pine forests, 1910-1949	(~2 %)
7.	Percent cover of spruce-fir forests, 1850-1909	(~2 %)
8.	Average interior area of lodgepole pine, pre-1850	(~1 %)
9.	Average interior size of lodgepole pine patches post-1950	(~1 %)
10.	Average interior size of spruce-fir patches, 1850-1909	(~1 %)

The ten major landscape characteristics, and some minor ones, were measured for each Reference Area. Landscape measurements of the Reference Areas were assumed to represent an average value within the "range of natural variability" that could be expected in relatively undisturbed landscapes. It should be noted that it is impossible to find a forested landscape of any size that has not had some disturbance (including fire suppression) by man since 1850, but the six roadless

areas used for Reference Areas were the only areas with available data that have not been harvested since 1950.

It was not possible to use the Huston Park, Encampment, River or Savage Run Wilderness Areas because no age data is available for forests. Wilderness status does not preclude human-caused changes which might affect landscape structure In fact, both the Encampment River and Platte River Wilderness were extensively tie-hacked.

Each watershed (BDU) was matched with the Reference Area that had the most similar cover type characteristics. Then the ten major landscape characteristics were quantified for each watershed and compared to the matched Reference Area. Each value for watershed measurements was divided by the matching value from the partner Reference Area which standardized the values so they could be compared among groups. The standardized landscape measurements were called indicator scores.

An indicator score close to 1.0 meant that a particular watershed measurement was similar to that of the Reference Area. Watersheds whose Indicator Scores for several characteristics differed widely from Reference Areas were considered to be far from the mean of expected "natural variation" for these several characteristics and, therefore, possibly at or beyond a natural range of landscape structure.

The concept of the "range of natural variability" addresses the variation over time of a suite of structural characteristics that resulted from various events, each of which had its own statistical properties including a mean value. It is not possible to quantitatively determine ranges of variation for the ten landscape characteristics, but it is possible to measure means of landscape characteristics and compare each watershed with a Reference Area.

Several statistical assumptions underlie the methodology of using mean values as a surrogate for evaluating ranges. If standard statistical distrubutions are assumed, then landscape variation can be described with statistical properties related to means and ranges such as standard deviations or variance.

The results of this analysis must be interpreted in light of these statistical assumptions and with the understanding that knowing a mean value is not equal to knowing the values for the full range of variation. Nonetheless, means are no less a long-term standard than ranges. Landscapes within some given range of natural variability should also have mean values for a given measurement close to the mean of the range of natural variability for that measurement.

This analysis uses a suite of scores to describe landscape structure using the indicator scores. Thus, a given watershed may have none to all of the set of scores far away from the mean values. This multivariate analysis approach allows different watersheds to be evaluated on different sets of characteristics.

Watersheds which had many Indicator Scores for Principal Components close to the means of the Reference Areas are:

Sierra Madre Northwest		Sierra Madre Southeast	
BDU	Name	BDU	Name
3	Big Sandstone Creek	23	Beaver Creek

Watersheds which had Indicator Scores for Principal Components far from the means of the Reference Areas are:

Sierra Madre - Encampment River		Sierra Madre Southeast	
BDU	Name	BDU	Name
18	South Fork Miner Creek	25	Bear Creek

Snowy Range North - West		Snowy Range South - Central	
BDU	Name	BDU	Name
32	Lower North Brush Creek	45	Mowberg Creek
33	Upper North Brush Creek	51	Boswell Creek
37	Middle French Creek	52	Bear Creek

Snowy Range North - East	
BDU	Name
63	West Medicine Bow River
65	Lower Medicine Bow River
66	East Medicine Bow River

The Indicator Score for watershed 25 differed from the Reference Area because of natural patchiness at lower elevations (i.e. natural patchiness because of substrate constraints did not permit a good match with Reference Areas). Other watersheds with most indicator scores far from the Reference Group means are highly fragmented by timber harvests and have patch sizes and other aspects of forest structure very different than unharvested landscapes. They are watersheds which may be at or beyond the natural range of variation for landscape structure. Details of this analysis of fragmentation are in (Baker 1994).

Watersheds with more than 15 percent of their area in clearcuts since 1950 are listed in Table 6.8. Measument of cumulative clearcut area is only one way to evaluate fragmentation. It does not include the effects of roads or partial cutting.

Table 6.8 Watersheds (BDUs) with more than 15 percent of their area cumulatively clearcut since 1950 (RIS database Fall 1994; and Baker 1994 Table 21).

BDU	% clearcut	Name
Sierra Madre - southeast		
24	18%	Middle Fork Big Creek
Snowy Range North - West		
30	23%	Pass Creek
32	27%	Lower North Brush Creek
33	16 %	Upper North Brush Creek
36	19 %	North Cottonwood Creek
37	29 %	Middle French Creek
38	15 %	Upper South French Cr.
Snowy Range North - East		
63	27 %	West Medicine Bow River
65	20 %	Lower Medicine Bow River
66	32 %	East Medicine Bow River
67	16 %	Wagonhound Creek
Snowy Range South - Central		
45	17 %	Mowberg Creek
49	18 %	Devils Gate Creek
50	23 %	Upper Douglas Creek

Watershed health analysis discussed in Chapter 7 and Appendix 14 includes these factors.

Acres clear cut and partial cut yearly from 1950-1994 are presented in Figure 6.33. The data are presented for each Biodiversity Area. Clear cutting has decreased overall or remained about the same in most BDAs but partial cutting has generally increased except in the east central and southeastern BDAs in the Medicine Bow Mountains where partial cutting has remained at a fairly constant low level.

Acreage figures which accompany Figure 6.34 are in Appendix 12. Cumulative acres harvested 1950-1994 are listed below:

	Clearcut	Partial Cut	Total	Sq. miles
Sierra Madre Mountains	16,668	13,791	30,639	47.9
Medicine Bow Mountains	54,485	33,529	88,014	137.5

These estimates do not include road area.

Cumulative areas with clear cuts, partial cuts, group shelterwood, cuts and total cuts are presented in Figure 6.35. A map of total cuts with a 60 meter edge influence zone is also presented (from Baker 1994 Figures 9 and 10).

The landscape measurements and analysis presented above are conservative because the GIS information did not include the fragmentation effects of roads. Road information was not available in 1994 when the analysis was done. Study is underway (Reed et al. 1996) to determine the added effect of roads on forest fragementation, edge, patch size and amount of interior forest on the Coon Creek Project area. The Coon Creek area is experimental, with a pattern of small patch clearcuts not typical of timber harvest patterns of the MBNF. Nonetheless, the results of this study demonstrate the changes in patch size, edge, and other characteristics as young forest (from clearcuts) accumulates in forest matrix of mostly mature lodgepole pine and spruce-fir.

Detailed study of the landscape structure of the southeastern Sierra Madre Mountains in the Encampment River and portions of adjacent watersheds was done by Reed et al. (1996). The study area (including the Coon Creek Project area) is about 15 percent of the area of the Medicine Bow National Forest. Clearcut cumulative effects were analyzed using two different maps - one with cover type and age and a second with habitat structural stages. Landscape metrics showing cumulative acres of clear cuts are in Figure 6.37. Many of these clearcuts are regenerating, but still provide a high-contrast edge and a patch with different biological diversity characteristics than adjacent unharvested forest.

Accumulation of clearcut areas less than 35 years old is shown in Figure 6.38 which depicts changes in time for number of patches, average patch size, average patch edge, and total edge when cumulative clearcuts are compared to a structural stage map for the Tie Camp Area. The number of patches created by timber harvest in the area changed from 26 in the 1950s to 491 by 1993. Patch size changed from about seven acres in the 1950s to about ten in the 1960s and

dropped to about four acres in the 1990s because of the effect of small patch cuts at Coon Creek (Reed et al. 1996).

Clearcut patches became increasingly dominant on the landscape from the 1960s-1990s. While the patterns of clearcutting in the Coon Creek project had a major impact on the landscape statistics, the trends toward fragmenting the landscape had begun before the Coon Creek watershed was harvested. In Coon Creek the forest is still the matrix and the clearcuts are the patches. In other harvested areas the clearcuts become the matrix and remnant forests become the patches (Ripple et al. 1991). Reversal of patches and matrix exists elsewhere on the Medicine Bow National Forest, but has not been quantified and analyzed.

It was possible to identify kinds of patterns created by the clear cuts in the context of different kinds of landscape features important to wildlife habitat and biological diversity. Landscape metrics are a powerful landscape analysis tool to provide measurements of change over time and relate them to the landscape structure which is being altered Exactly what these changes mean for wildlife populations and ecosystem function cannot be specified at this time.

SUCCESSION IN CLEARCUTS

A survey of succession in clearcuts was conducted in 1993 by MBNF staff (Appendix 16). The purpose of the survey was to determine successional patterns in clearcuts using percent cover of trees, shrubs, forbs, and grasses and to determine species compostion of tree regeneration.

Data were obtained from clearcuts from 1952-1992 in 53 stands of lodgepole pine and spruce-fir cover types and in uncut control stands in the Medicine Bow Mountains. Sites were stratified into six age groups: uncut (control stands), and by the first few years of the five decades from 1950 to 1992. Thus there were 7-10 years between decade groups. Species composition and percent cover of vascular plants were recorded for understory species in a 50m x 50m plot. Tree species and size (seedling, sapling, pole, mature) were measured for lodgepole pine, Engelmann spruce, subalpine fir and aspen in a smaller 20m x 50m plot nested in the larger plot.

Soil samples and root samples from conifer and *Vaccinium* were taken. Soil fertility and mycorrhizal infection levels of roots were analyzed under direction of Dr. S.E. Williams of the Department of Plant, Soil and Insect Sciences, University of Wyoming, and graduate students Zhipeng Zhao and Vicki Whittendowse.

Gradient analysis of understory shrubs, forbs, and grasses produced eleven groups divided into lodgepole pine (4 groups) and spruce-fir or mixed conifer (7 groups).

See Figures in Appendix 16. The dominant understory types in the four lodgepole pine groups were: 1) large shrubs (buffaloberry, common juniper, rose, currant), 2) kinnikinnik, 3) elk sedge and Ross sedge, and 4) forbs, particularly lupine. The four lodgepole pine groups had regeneration dominated by lodgepole pine, or lodgepole pine and subalpine fir. Subalpine fir was the primary species in the higher elevation groups. Lodgepole pine seedling frequency was half or less than fir in five of the seven groups.

Understory composition of lodgepole pine stands cut in the 1950s, which had not been rollerchopped, were similar to uncut stands. *Vaccinium* was present in several of the stands (often present with large shrubs), but was not a dominant in any of the groups.

Spruce-fir control stands had a predominance of *Vaccinium*. Percent cover of *Vaccinium* decreased across the moisture gradient to zero in spruce-fir stands at the wet end of the gradient. These two groups were composed of high elevation (above 10,000 feet) clearcuts of the 1970s in areas now dominated by grasses and sedges. Two other spruce-fir groups had mainly forbs and "weedy" species (clearcuts of the 1980s-1990s), while older clearcuts on drier sites had mainly *Vaccinium*, currant, and elk sedge. Only in the two riparian groups was spruce reproduction well-represented or co-dominant with subalpine fir.

Mycorrhizal infection of conifer roots was highly correlated with the first Ordination Axis (moisture gradient). Mycorrhizal infection of conifer roots increased with drier sites and older stands (Photo EM-1,2). The same general trend was true for *Vaccinium* mycorrhizal infection, but *Vaccinium* did not occur in all stands.

The conclusions from the survey are:

1. Clearcuts enhance species richness if only vascular plants are counted. If moss, fungal, and lichen species and macroinvertebrates were included, the uncut spruce-fir forest would be the most diverse. See Appendix 7 and Blake's tables at the beginning of Chapter 7.

2. Engelmann spruce reproduction is not well-represented in comparison to lodgepole pine and subalpine fir. The regeneration might better be termed fir-spruce forests (indeed they are often described that way in the literature as Abla-Pien codominants). Thus, although mature Engelmann spruce may have been an important timber volume species for the clearcut harvest, it may not be establishing adequately for the planned next harvest in the rotation. The same pattern was observed but not measured in many partial cut areas.

3. Large individuals of buffaloberry and common juniper shrubs are present in stands cut in the 1950s, but shrub presence and development appears to be sparse to absent in stands cut after 1970. This may be due to normal successional processes, but it may also be due to destruction of shrub crowns from rollerchopping. Thus, the diversity of shrubs in the years 2010-2030 from stands cut in 1970-1990 may be different that what is observed now (1993) in stands cut in the 1950s because of post-harvest treatment.

4. The effect of grazing on species composition and succession could not be quantitatively evaluated in this study, but field observations suggested that palatable species are removed on lodgepole sites in the southern Medicine Bow Mountains adjacent to roads or meadows and easily accessible to livestock. Grazing tolerant species (clover, dandelion, strawberry) or unpalatable species (*Senecio eremophilus*, various annuals) are dominant on these sites and succession may be affected by livestock herbivory.

5. The practice of seeding clearcuts with native grasses should be continued in the interest of soil productivity and herbage production for multiple use livestock grazing and wildife benefits. There is no evidence that bunch grass seeding causes competition detrimental to tree reproduction on the Medicine Bow National Forest. At high elevations natural propagules of rhizomatous grasses and sedges may compound problems with tree regeneration caused by environmental limitations.

LICHEN BIOLOGICAL DIVERSITY

In the summer of 1994 MBNF staff conducted a follow-up study to the succession inventory of 1993 in 24 of the stands from the succession in clearcuts study. These sites and adjacent uncut stands were surveyed for presence and condition of lichens. Adjacent uncut sites were also surveyed. General discussion of lichens and details of the lichen survey are in Appendix 7.

Sites from 10 of the 11 Ordination Groups (See Appendix 16), representing the spectrum of clearcut ages from 1950-1992, were selected for the lichen survey. Lichens were collected from rocks (saxicolous lichens), live tree trunks, and branches (corticolous lichens), soil, and decaying woody material. Lichens from trees, soil, and decaying wood were sorted and tentatively identified by Mr. Tim Chumley, a student in the Botany Department at the University of Wyoming. Lichen species at the Rocky Mountain Herbarium, previouly collected and identified, were used as reference specimens. Samples of the most common species were sent to the Cryptogam Herbarium at Brigham Young University, Provo, Utah, for verification by Dr. Larry St. Clair. Voucher specimens are also at the Cryptogam Herbarium.

Rock lichens on outcrops that were not rollerchopped appeared healthy and not affected very much by clearcutting. Soil lichens received mechanical damage from heavy equipment and were often demolished by abrasion or burial by soil and woody debris from rollerchopping. Cryptogamic cruts (soil lichens on dry, thin soils of lower elevation lodgepole pine forests) were destroyed wherever heavy equipment and rollerchopping were used (Photos E-101, E-102, E-104). One clearcut stand was broadcast burned, and all lichens (including rock lichens) were removed.

In most uncut stands (both lodgepole pine and spruce-fir) lichens, especially *Cladonia*, were found commonly, often with moss (Photos E-99 and E-100), on decaying wood. Mosses and nearly all lichens were absent from the clearcut stands. In some of the 1950s clearcuts, mosses were beginning to reestablish sparsely, and tiny lichen colonies were evident on both wood and on soil.

Epiphytic lichens in the genera *Bryoria* and *Usnea* (found on tree branches or trunks) (Photo E-110) are uncommon in the Medicine Bow Mountains. They are found mainly in older forests, especially forests 200 years or older. They occur mainly on subalpine fir trees and often on north facing slopes or moist, lower topographic postions. *Bryoria* and *Usnea* also occurred on lower, dead branches of spruce. Casual observation of occurrence of these species suggested that they are usually found with riparian old growth and old growth on north-facing slopes generally between about 8500 and 9500 feet. Good populations of epiphytic lichens were seen incidentally along the Pass Creek Road, the north-facing slope of French Creek, and along road 496 in the Sierra Madre Mountains in the East Fork watershed above the confluence with Coon Creek.

Spruce and lodgepole pine have few to no bark lichens, but subalpine fir is usually covered with them. Many species occur on the trunks, especially on younger trees, and branches and twigs are crusted with lichens.

Some lichens fix nitrogen. In other ecosystems (Canada and Alaska) they are known to be important in the nutrient budget of ecosystems. Lichens in the Rocky Mountains have not been studied very much and their role in forests is less well known than in boreal systems.

It was difficult to find completely uncut (not partial cut) stands of spruce-fir near some of the clearcuts at higher elevations in the northern Medicine Bow Mountains, especially in the Bow River and Rock Creek watersheds. Some watersheds have extensive areas which have received both clearcut and partial cut harvests since 1950. Partial cutting on the moraines near kettleholes, in leave strips and over larger areas of old spruce-fir or late-seral lodgepole forests appears to have eliminated or damaged most populations of soil lichens, decaying wood lichens, epiphytic lichens, and mosses.

Microclimate conditions in partial cut stands become windier, brighter, drier, and subject to different temperature extremes and snowfall regimes. Apparantly these changes do not permit the continued survival of lichens and mosses. Decay processes also appear to be slow to missing, judging by the weathering, but not decaying, wood in these stands. Reduction of biological diversity of lichens also reduces the diversity of macroinvertebrates in these communities, with concomitant effects of food chains for small mammals and birds. Thus both clearcutting and partial cutting appear to have effects, which need further study, on biological diversity of less charismatic, but widespread, members of old forest communities.

There is concern in many parts of the world about loss of lichen biological diversity due to air pollution. That does not appear to be a serious threat here, but there does appear to be considerable attenuation of lichen biological diversity as a result of environmental changes associated with timber harvest.

Forest Age Continuity

Indices of Ecological Continuity (IEC) have been developed by several investigators in Europe (Rose, 1976) and northern New England and Canada (Selva, 1994) using lichens. The IEC can be used to assign a numerical indication of extent of ecological continuity over time to forest stands and are being used to identify old growth forests in the northeastern United States. Certain species of lichens appear to be "faithful" to ancient forests and are found only in old forests which have not been disturbed by post-colonial fire and logging. Selva (1994) developed separate indices for hardwood forests and spruce-fir forests on National Forests in New England.

Selva (1994) found 15 species of lichens occurred only in old spruce-fir forests, and additional species were found in old forests of both hardwoods and conifers. Epiphytic lichens were especially important as indicators of old stands which may have forest continuity for many generations of trees in these uneven age systems. Because disperal of lichens on decaying wood is limited and they require a constant supply of specialized substrates found only in these forests, they are excellent indicators of ancient forests with long ecological continuity. Data in table AP7.3 in Appendix 7 (Lichen biological diversity) suggest that it would be possible to develop similar indices for old forests on the MBNF.

ASPEN FORESTS

Distribution of aspen forests for the Sierra Madre and Medicine Bow Mountains is shown in Figure 6.38. Acreages of upland aspen stands in each watershed are in Appendix 11. Aspen occurs in widely scattered small stands in the Laramie Mountains. It is primarily a riparian cover type in both the Laramie Mountains

and Sherman Mountians. Aspen occurs in canyons at the perimeter of all mountain ranges in the MBNF.

Aspen occupies large areas in a variety of topographic positions in the southwestern Sierra Madre Mountains west of the Continental Divide. Most aspen in that area appears to have originated after the fire(s) in 1841 resulting from Indian-fur trapper conflicts. The cover type composition of the area prior to 1841 is not known for certain, but there was likely more coniferous forest than at present. In many areas, lodgepole pine and subalpine fir form a substantial understory beneath aspen.

Aspen forests support a diverse array of birds and small mammals. The aspen forests of the Southwestern Sierra Madre add a component of diversity which is not found elsewhere on the MBNF because aspen occurs in rather restricted areas elsewhere. Severson (1963) described and classified the aspen stands in the Sierra Madre Mountains. The largest aspen found by Severson (1963) was 25.9 inches DBH. Shepperd (1990) presented a broader classification of aspen in the Central Rocky Mountains.

Most aspen occurs in grazing allotments. Livestock effects on aspen regeneration are variable. Understories of aspen are attractive to both cattle and wildlife. Browsing and trampling interferes with aspen regeneration, especially in the Laramie Mountains where soil and climate conditions are not especailly favorable for aspen. Aspen regeneration has been an important component of several grazing allotment plans in the Laramie Mountains (Erhard 1989; Booth 1992).

Aspen is susceptible to a variety of fungal diseases and insect parasites. Cankers caused by *Cytospora* spp. and *Encoelia* are common (Geils, personal communication). Both may be fatal. Diseases and parasites occur ubiquitously throughout the area.

SHRUBLANDS AND GRASSLANDS

Shrublands and grasslands will be discussed together because they form landscape mosaics. High elevation shrublands and alpine grasslands were discussed with alpine and timberline ecosystems. Distribution of upland grassland and shrubland cover types is in Figure 6.2.

Small areas of upland grasslands occur in the lodgepole pine and spruce-fir forests on the Medicine Bow and Sierra Madre Mountains. Exceptions to this are Cinnabar Park and Dry Park in the southern Medicine Bow Mountians which occur on unusual soil substrates. These areas have mainly Idaho fescue cover.

Upland grasslands interspersed with shrublands occur around the perimeter of the Sierra Madre and Medicine Bow Mountains, mostly below lower treeline on alluvial substrates. These are bunchgrass systems with Idaho fescue, bluebunch wheatgrass and various species of needlegrass as dominant members. Shrubs are mainly sagebrush with some antelope bitterbrush.

In the Sherman Mountains mountain mahogany is found along with sagebrush and bitterbrush. Mountain mahogany is restricted to sedimentary rock substrates. Large patches of grassland without a significant shrub component occur in the Sherman Mountains. Some of these open areas are categorized as forblands in the RIS database. Species composition of these grasslands and shrublands is more similar to the Front Range and Great Plains than it is to the Medicine Bow and Sierra Madre Mountains.

Extensive grassland/shrubland mosaics occur in the Laramie Mountains. Skunkbrush sumac and bitterbrush are found near the eastern forest border near Esterbrook. In both the Laramie Mountains and Sherman Mountains the grassland-shrubland complex is interspersed with open ponderosa pine forest.

Nearly all grassland-shrubland and ponderosa pine bunchgrass ecosystems on the MBNF are in grazing allotments. Impacts of grazing will be the subject of a separate analysis during the Forest Revision. In 1975 Currie produced a Research Station paper on grazing management of ponderosa pine-bunchgrass ranges of the Central Rocky Mountains. This was followed in 1976 by a report entitled *Management of mountain grasslands in the Central Rockies: The status of our knowledge* in 1976 (Turner and Paulsen, 1976).

Cook et al. (1994) did some experimental burning in the Sierra Madre and Medicine Bow Mountains in grass-shrub ecosystems. They concluded that prescribed burning in ecosystems with big sagebrush, antelope bitterbrush, mountain mahogany, and Saskatoon serviceberry improved twig production of shrubs and increased protein content in herbaceous plants. They suggested that including prescribed burning in range management of these ecosystems would improve diet quality for large herbivores during the growing season. Limited areas of prescribed burns are done by Districts to remove sagebrush or stimulate growth in fire-adapted shrubs used by wildlife.

Evaluation of composition and condition of herbaceous vegetation is needed in many riparian areas, some uplands, and seeded clearcut areas. Early seral stages, or plants that are unpalatable or resistant to grazing prevail in many areas. If species such as Kentucky bluegrass, strawberry, dandelion and clover predominate in riparian areas, it is likely that native plants of later seral stages are unable to colonize sites because of herbivory and mechanical disturbance.

Seral stages can be evaluated by the species composition of shrubs and herbaceous vegetation, while condition can be evaluated by plant physical health, physiological capability and general vigor plus ecosystem characteristics such as soil exposure and stability. A generalized seral stage/vegetation condition matrix illustrates relationships among these two vegetation attributes (Table 6.39):

Table 6.9 Seral stage and ecosystem condition

Seral stage	Condition		
	Poor	Fair	Good
Earlier stages	1	2	3
Later stages	4	5	6

Thus it is possible to have both earlier or later seral stages in different condition classes, and both biological diversity and ecological integrity can be assessed.

Noxious weeds are localized mainly in lower elevation riparian areas on the west side of the Sierra Madre and Medicine Bow Mountains, the southern Laramie Mountains and LaBonte Canyon. Musk thistle, Canada thistle and yellow toadflax are the major species. Spotted knapweed has recently been found near the Forest boundary in the western Sierra Madre mountains. For the most part, native species predominate on the MBNF, although there is widespread occurrence at lower elevations of non-native species such as smooth brome, timothy, Kentucky bluegrass, several wheatgrass species and a host of forbs including dandelion, alfalfa, clover, and sweetclover (Appendix 5). Where livestock grazing occurs, especially in conjunction with disturbance from clearcuts since 1950, herbaceous vegetation may be kept in early seral stages or shrubs may have difficulty establishing.

LITERATURE CITED

Alexander, M.E. 1975. A preliminary reference list on the significance of fire in the forest communities of the Colorado Rockies. Part I. Upper montane (partial), subalpine and alpine Unpublished report. Department of Forest and Wood Sciences. Colorado State University Fort Collins, CO.

Alexander, M.E.; Hawksworth, F.G. 1975. Wildland fires and dwarf mistletoes: A literature review of ecology and prescribed burning. USDA Forest Service General Technical Report RM-14 Fort Collins, CO.

Alexander, M.E.; Hawksworth, F.W. 1976. Fire and dwarf mistletoes in North American coniferous forests. Journal of Forestry 74(7): 446-449.

Alexander, R.R. 1974. Silviculture of subalpine forests in the central and southern Rocky Mountains: The status of our knowledge. USDA Forest Service Research Paper RM-121 Fort Collins, CO.

Amman, G.D. 1977. The role of the mountain pine beetle in lodgepole pine ecosystems: impact on succession. IN: The Role of Arthropods in Forest Ecosystems. Mattson, W.J. (ed.) pages 3-18 Spring-Verlag, New York.

Amman, G.D. 1978. Biology, ecology and causes of outbreaks of the mountain pine beetle in lodgepole pine forests. IN: Theory and practice of mountain pine beetle management in lodgepole pine forests. Kibbee et al., (eds.) pages 39-53. University of Idaho, Moscow, ID.

Amman, G.D.; McGregor, M.D.; Cahill, D.B.; Klein, W.H. 1977. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the the Rocky Mountains. USDA Forest Service GTR INT-36. Ogden, UT.

Aplet, G.H.; Laven, R.D.; Smith, F.W. 1988. Patterns of community dynamics in Colorado Engelmann spruce-subalpine fir forests. Ecology 69(2): 312-319.

Arno, S.F. 1976. The historical role of fire on the Bitterroot National Forest. USDA Forest Service Research Paper INT-87 Odgen, UT.

Arno, S.F. 1980. Forest fire history in the Northern Rockies. Journal of Forestry 78(8): 460-465.

Austin, D.D.; Perry, M.L. 1979. Birds in six communities within a lodgepole pine forest. Journal of Forestry Sept. 1979: 584-586.

Averill, C.C. 1964. A report on the condition of the spruce-fir cutover areas of the the Rocky Mountain Region. USDA Forest Service, Lakewood, CO.

Baker, W.L. 1994. Landscape structure measurements for watersheds in the Medicine Bow National Forest using GIS analysis. Department of Geography and Recreation. University of Wyoming. Contract for the Medicine Bow National Forest, Laramie, WY.

Baker, W.L.; Cai, Y. 1992. The r.le programs for multiscale analysis of landscape structure using the GRASS Geographical Information System. Landscape Ecology 7(4): 291-302.

Barrett, S.W. 1980. Indian fires in the pre-settlement forests of western Montana. IN: Proceedings - Fire History Workshop USDA Forest Service General Technical Report RM-81. Fort Collins, CO.

Barrett, S.W. 1981. Relationship of Indian-caused fires to the ecology of western Montana Forests. Master's Thesis University of Montana, Bozeman, MT.

Barrett, S.W.; Arno, S.F. 1982. Indian fires as an ecological influence in the northern Rockies. Journal of Forestry 80(10): 3-17.

Bates, C.G. 1932. Forests and stream flow. American Society of Civil Engineers, Discussions Pages 1288-1293.

Bates, C.G.; Henry, A.J. 1928. Forest and streamflow experiment at Wagon Wheel Gap, Colorado. Supplement 30. Washington, D.C.

Bates, C.G.; Hilton, H.C.; Krueger, T. 1909. Experiments in the silvicultural control of natural reproduction of lodgepole pine in the Central Rocky Mountians. Journal of Agricultural Research 38(4): 229-243.

Baumgartner, D.M. 1973. (ed). Management of lodgepole pine ecosystems Symposium Proceedings Vols I and II. Washington State University Pullman, WA.

Baumgartner, D.M.; Krebill, R.G.; Arnott, J.T.; Weetman, G.F. 1984. Lodgepole pine: The species and its management (Symposium Proceedings) Cooperative Extension. Washington State University.

Beal, J.A. 1943. Relation between tree growth and outbreaks of the Black Hills beetle. Journal of Forestry 41: 359-366.

Berntsen, C.M. 1967. Relative low temperature tolerance of lodgepole pine and ponderosa pine seedlings. PhD Thesis. Oregon State University, Corvallis, OR.

Berntsen, C.M. 1973. Management conflicts in lodgepole pine. pages 503-515 IN: Management of lodgepole pine ecosystems Symposium Proceedings. Washington State University, Pullman, WA.

Bevenger, G.S.; Troendle, C.A. 1987. The Coon Creek water yield augmentation pilot project. IN: Management of Subalpine Forests: Building on 50 years of Research USDA Forest Service General Technical Report RM-149. Fort Collins, CO.

Billings, W.D. 1957. Replacement of spruce-fir forest by alpine tundra as a result of fire (Abstract). Bulletin Ecological Society of America 38: 70.

Billings, W.D.; Bliss, L.C. 1959. An alpine snowbank environment and its effects on vegetation, plant development, and productivity. Ecology 40(3): 388-397.

Billings, W.D. 1969. Vegetational pattern near alpine timberline as affected by fire-snowdrift interactions. Vegetatio 19: 192-207.

Billings, W.D.; Mooney, H.A. 1959. An apparent frost hummock-sorted polygon cycle in the alpine tundra of Wyoming. Ecology 40(1): 16-21.

Bliss, L.C. 1956. A comparison of plant development in microenvironments of Arctic and Alpine tundras. Ecological Monographs 26(4): 303-337.

Blunt, B. 1980. Wildlife habitat and successional stages of vegetation on lodgepole pine forests. Unpublished specialist report. Medicine Bow National Forest. Laramie, WY.

Booth, M. 1992. Douglas Ranger District Range Technician - personal communication.

Bradley, A.F.; Fischer, W.C.; Noste, N.N. 1992. Fire ecology of the forest habitat types of Eastern Idaho and Western Wyoming. USDA Forest Service General Technical Report INT-290. Ogden, UT.

Brown, G.R. 1994. Annual Report for the Coon Creek Wildlife Project. RMFRES Laramie, WY.

Brown, P.M. 1994. Fire history of the Southern Black Hills, South Dakota. Final Report for Cooperative Agreement 28-C3-776 RMFRES Fort Collins, CO.

Brown, P.M. 1995. Oldest known Engelmann spruce. USDA Forest Service Research Note RM-RN-534. Fort Collins, CO.

Buckner, D.L. 1977. Ribbon forest development and maintenence in the Central Rocky Mountains of Colorado. PhD Dissertation University of Colorado Boulder, CO.

Cartwright, T.C. 1994. Forest Biologist, Medicine Bow National Forest. Personal communication.

Clements, F.E. 1910. The life history of lodgepole burn forests. USDA Forest Service Bulletin 79 Washington, D.C.

Cochran, P.H.; Berntsen, C.M. 1973. Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures. Forest Science 19(4): 272-280.

Cook, J.G.; Hershey, T.J; Irwin, L.L. 1994. Vegetative response to burning on Wyoming mountain-shrub big game ranges. Journal of Range Management 47: 296-302.

Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwestern pine forests since settlement. Ecological Monographs 30: 129-164.

Covich, A.; Rudman, B.; Smith, S.; Kennedy, P.; Cooper, D.; Fausch, K.; Wilson, K. 1994. Literature review on the range of natural variation in the Colorado Front Range and associated grasslands. Prepared for the Arapaho-Roosevelt National Forest at Colorado State University, Fort Collins, CO.

Covington, W.W.; Moore, M.M. 1994. Southwestern ponderosa forest structure: Changes since Euro-American settlement. Journal of Forestry 92: 39-47.

Crane, M.F. 1982. Fire ecology of Rocky Mountain Region Forest habitat types. Final Report Department of Botany University of Montana Missoula, MT. Contract No 43-82x9-1-884 from Region 2 Rocky Mountain Region Denver, CO.

Crompton, B.J. 1994. Songbird and small mammal diversity in relation to timber management practices in the northwestern Black Hills. Master's Thesis University of Wyoming, Laramie, WY.

Crouch, G.L. 1987. Big game habitat research in subalpine forests in the Central Rocky Mountains. IN: Management of Subalpine Forests: Building on 50 years of Research. USDA Forest Service General Technical Report RM-149.

Critchfield, W.B. 1985. The late Quaternary history of lodgepole pines and jack pines. Canadian Journal of Forestry Research. 15: 749-772.

Currie, O.P. 1975. Grazing management of ponderosa pine-bunchgrass ranges in the Central Rocky Mountains. USDA Forest Service RM-159. Foret Collins, CO.

Davis,, R.; Brown, D.E. 1989. Role of post-Pleistocene dispersal in determining the modern distribution of Abert's squirrel. Great Basin Naturalist 49(3): 426-434.

Despain, D.G. 1983. Non-pyrogenous climax lodgepole pine communities in Yellowstone National Park. Ecology 64(2): 231-234.

Dieterich, J.H. 1983. Fire history of southwestern mixed conifer: a case study Forest Ecology and Management 6: 13-31.

Dinoor, A.; Eshed, E.. 1984. The role and importance of pathogens in natural plant communities. Annual Review of Phytopathology 22: 443-466.

Dix, R.L.; Richards, J.D. 1976. Possible changes in species structure of the subalpine forest induced by increased snowpack. IN: Ecological impacts of snow augmentation in the San Juan Mountain of Colorado. San Juan Ecology Project Bureau of Reclamation.

Dunford, E.G. 1944. The forests and your water supply. Western Farm Life Feb. 22, 1944.

Dunford, E.G.; Neiderhof, C.H. 1944. Influence of aspen, young lodgepole pine and open grassland types upon factors affecting water yield. Journal of Forestry 42: 673-677.

Earle, C.J. 1993. Forest dynamics in a forest-tundra ecotone, Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Washington, Pullman, WA

Earle, C.J. 1993. Personal communication regarding tree ages of Sheep Mountian.

Fahey, T.J. 1983. Nutrient dynamics of aboveground detritus in lodgepole pine (*Pinus contorta* ssp. latifolia) ecosystems, southeastern Wyoming. Ecological Monographs 53(1): 51-72.

Fahey, T.J.; Yavitt, J.B.; Pearson, J.A.; Knight, D.H. 1985. The nitrogen cycle in lodgepole pine forests, southeastern Wyoming. Biogeochemistry 1: 257-275.

Fischer, R.F.; Jenkins, M.J.; Fischer, W.F. 1987. Fire and the prairie-forest mosaic of Devil's Tower National Monument. American Midland Naturalist.

Fischer, W.C.; Clayton, B.D. 1983. Fire ecology of Montana forest habitat types east of the Continental Divide. USDA Forest Service General Technical Report INT-141 Odgen, UT.

Finch, D.; Fletcher, R. 1994. Silvicultural effects on birds in the Rockies. Forestry Research West April, 1994 USDA Forest Service.

Finch, D.M.; Reynolds, R.T. 1987. Bird responses to understory variation and conifer succession in aspen forests. IN: Emerick et al. (eds.) Issues and technology in the management of impacted wildlife. Thorne Ecological Foundation. Boulder, CO.

Forsyth, J.K. 1980. Principal components analysis of subalpine vegetation on the east slope of the Colorado Rocky Mountains. PhD Thesis University of Colorado, Boulder, CO.

Fox, D.G., Schoettle, A.W.; Vertucci, F.A. 1987. Glacier Lakes Ecosystem Experiments Site: An "Experimental" Wilderness IN: Management of Subalpine

Forests: Building on 50 Years of Research USDA Forest Service General Technical Report RM-149 Fort Collins, CO.

Franklin, J.F. 1993. Lessons from old growth. Journal of Forestry 91(12): 11-13.

Franklin, T.L.; Laven, R.D. 1989. Fire influences on Central Rocky Mountain lodgepole pine stand structure and composition. IN: Proceedings 47th Annual Tall Timbers Fire Ecology Conference Fire Research Institute, Roslyn, WA.

Gara, R.I.; Littke, W.R.; Agee, J.K.; Geiszler, D.R.; Stuart, J.D.; Driver, C.H. 1984. Influence of fires, fungi and mountain pine beetles on development of a lodgepole pine forest in south-central Oregon. IN: Lodgepole pine the species and its management pp. 153-169. Spokane, WA.

Gary, H.L. 1974. Snow accumulation and snowmelt as influenced by a small clearing in a lodgepole pine forest. Water Resources Research 10(2): 348-353.

Gary, H.L. 1980. Patch clearcuts to manage snow in lodgepole pine. Symposium, Boise Idaho, Jul 21-23, 1980). Irrigation and Drainage Divsion, American Society of Civil Engineers. pp. 335-346.

Geils, B.W. personal communication. Forest Pathologist - RMFRES
Fort Collins, CO.

Geils, B.W. 1984. Comandra blister rust damage and development on lodgepole pine. PhD Dissertation. Colorado State University Fort Collins, CO.

Geils, B.W.; Jacobi, W.R. 1987. Comandra blister rust: A threat to lodgepole pine IN: Management of Subalpine Forests: Building on 50 Years of Research. USDA Forest Service General Technical Report RM 149 Fort Collins, CO.

Geils, B.W.; Jacobi, W.R. 1989. Rating a lodgepole pine forest for potential losses to comandra blister rust IN: Rusts of Pine Proc. 3rd IUFRO Rusts of Pine, Working Party Conference Banff, Alberta CAN Northwest Reg., North. For. Cent. Edmonton, Alberta, Canada.

Gill, L.S.; Hawksworth, F.G. 1964. Dwarf mistletoe of lodgepole pine. USDA Forest Service Forest pest leaflet 18 Fort collins, CO.

Goldblum, D.; Veblen, T.T. 1992. Fire history of a ponderosa pine/Douglas fir forest in the Colorado Front Range. Physical Geography 12(2): 133-148.

Grasso, D.N., Thybony, S., Rosenberg, R.; Rosenberg, E. 1981. Cultural Resource Overview - Medicine Bow National Forest Vol. 1. High Plains Consultants Contract No 53-82X9-1-122, USDA Forest Service. Laramie, WY.

Greater Yellowstone Postfire Ecological Assessment Workshop. 1989. Ecological consequences of the 1988 fires in the Greater Yellowstone Area Final Report of the Greater Yellowstone Postfire Ecological Assessment Workshop.

Gruell, G.E. 1983. Indian fires in the interior west: a widespread influence. IN: Lotan et al (tech. coord.) Symposium and workshop on wilderness fire USDA Forest Service General Technical Report INT-182 Ogden, UT.

Gruell, G.E. 1985. Fire on the early western landscape: an annotated record of wildland fires 1776-1900. Northwest Science 59: 97-107.

Grumbine, R.E. 1990. Viable populations, reserve size and Federal Lands management: A Critique. Conservation Biology 4(2): 127-134.

Hadley, J.L. 1986. Effects of wind on leaf dessication and mortality in Wyoming timberline conifers: influence on krummholz growth forms. PhD Dissertation University of Wyoming, Laramie, WY.

Hadley, J.L.; Smith, W.K.. 1986. Wind effects on needles of timberline conifers; seasonal influence on mortality. Ecology 67: 12-19.

Hadley, J.L.; Smith, W.K. 1989. Wind erosion of leaf surface wax in alpine timberline conifers. Arctic and Alpine Research 21: 392-398.

Harris, L.D. 1984. The fragmented forest: island biogeography theory and the preservation of biotic diversity. University of Chicago Press.

Hawksworth, F.G. 1958. Survey of lodgepole pine dwarf mistletoe on the Roosevelt, Medicine Bow, and Bighorn National Forests. USDA Forest Service Station Paper RM-35 Fort Collins, CO.

Hawksworth, F.G. 1975. Dwarf mistletoe and its role in lodgepole pine ecosystems. IN: Management of lodgepole pine Ecosystems Symposium. D. Baumgartner, Ed. pages 342-358 Washington State University Pullman, WA.

Hawksworth, F.G.; Weins, D. 1972. Biology and classification of dwarf mistletoes. Agriculture Handbook 401. USDA Forest Service Washington, D.C.

Hawksworth, F.G.; Weins, D. 1995. Dwarf mistletoes: biology, pathology and systematics. USDA Agriculture Handbook 709. Washington, DC. (In press).

Hawksworth, F.G.; Moir, W.H.; Janssen, J.E. 1992. Effects of dwarf mistletoe in old-growth lodgepole pine stands at Fraser Experimental Forest, Colorado. IN: Old growth forests in the Southwest and Rocky Mountain Regions: Proceedings of a

Workshop USDA Forest Service General Technical Report RM-213 Fort Collins, CO.

Hendrickson, W.H. 1972. Perspective on fire and ecosystems in the United States. Pages 29-33 IN : Proc. of the Symposium on Fire and the Environment FS 276 USFS and North Amrican Forestry Commission Washington, D.C.

Hilton, H.C. 1930. Memorandum to Forest Officers regarding spruce budworm outbreak in Douglas fir adjacent to the Platte River. November 29, 1930. Medicine Bow Collection American Heritage Center, Laramie, WY.

Honaker, J.J. 1995. Fire history of the southern Sierra Madre Mountains, Wyoming Master's Thesis University of Wyoming Laramie, WY.

Hoover, M.D. 1969. Vegetation management for water yield. American Water Resources Association Symposium. Water Balance North Anerica (Banff, Alberta, June, 1969). Proceedings Series 7: 191-195.

Hoover, R.L.; Wills, D.L. 1987. Managing Forested Lands for Wildlife. USDA Forest Service and Colorado Division of Wildlife. Eastwood Printing and Publishing Co. Denver, CO.

Jacobi, W.R.; Geils, B.W.; Taylor, J.E.; Zenta, W.R. 1993. Predicting the incidence of comandra blister rust on lodgepole pine: site, stand and alternate host influences. Phytopathology 83(6): 630-637.

Johnson, D.W.; Hawksworth, F.G.; Drummond, D.B. 1978. 1977 dwarf mistletoe loss assessment survey, Medicine Bow National Forest, Wyoming. USDA Forest Service , Forest Insect and Disease Management., Methods Application Group Report 78-1.

Johnson, W.M. 1962. Vegetation of high-altitude ranges in Wyoming as related to use by game and domestic sheep. University of Wyoming Agricultural Experiment Station Bulletin 387 Laramie, WY.

Johnson, E.A.; Miyanishi, K.; Kleb, H. 1994. The hazards of interpretation of static age structures as shown by stand reconstructions in a Pinus-contorta-Picea engelmannii forest. Journal of Ecology 82(923-931).

Jones, G.P. 1989. Report on the Ashenfelder Basin Special Interest Area. Purchase Order 40-8508-8-670 Medicine Bow National Forest Laramie, WY.

Keller, M.E.; Anderson, S.H.. 1992. Avian use of habitat configurations created by forest cutting in southeastern Wyoming. The Condor 94: 55-65.

Knight, D.H.; Running, S.W.; Fahey, T.J. 1985. Water and nutrient outflow from contrasting lodgepole pine forests in Wyoming. Ecological Monographs 55(1): 26-48.

Knight, D.H. et al. 1975. The Medicine Bow ecology project. Final Report. Contract No, 14-06-D-7198 among the Wyoming Water Resources Institute, the U. S. Forest Service, the Rocky Mountain Forest and Range Experiment Station and the University of Wyoming.

Knight, D.H.; Yavitt, J.B.; Joyce, G.D. 1991. Water and nitrogen outflow from lodgepole pine forest after two levels of tree mortality. Forest Ecology and Management 46:215-225.

Knight, D.H. 1994. Mountains and plains: The ecology of Wyoming landscapes. Yale University Press.

Larson, L. L. 1978. Vegetative variablity along a gradient from lodgepole pine - spruce-fir. PhD Dissertation. Colorado State University, Fort Collins, CO.

Laven, R.D. 1995. Personal Communication. Lecture on fire in Rocky Mountain Ecosystems. RMFRES, Fort Collins, CO March 7, 1995.

Laven, R.D.; Omi, P.N.; Wyant, J.G.; Pinkerton, A.S. 1980. Interpretations of fire scar data from a ponderosa pine ecosystem in the Central Rocky Mountains, Colorado pages 46-49 IN: Proc. of the Fire History Workshop USDA Forest Service General Technical Report RM-81 Fort Collins, CO.

Leaf, C.F. 1975. Watershed management in the Rocky Mountain subalpine zone: The status of our knowledge USDA Forest Service Research Paper RM-137. Fort Collins, CO.

Lexen, B. 1949. Alternate clear-strip cutting in the lodgepole pine type. USDA Forest Service Station Paper Number 1, Fort Collins, CO.

Little, E.L., Jr. 1971. Atlas of United States trees. Volume 1. Conifers and Important Hardwoods. USDA Forest Service Miscellaneous Publication 1146. Washinton, D.C.

Lotan, J.E. 1974. Cone serotiny - fire relationships in lodgepole pine. IN: Proceedings Tall Timbers Fire Ecology Conference No. 14 and Intermountain Fires Research Council and Land Management Symposium pages 267-278.

Lotan, J.E.; Brown, J.K.;Neuenschwander, L.F. 1984. Role of fire in lodgepole pine forests. IN: Baumgartner et al. Lodgepole pine the species and its management. pages 133-152 Washington State University Pullman, WA.

Lundquist, J.E.; Lister, C.K. 1991. Forest Pest Conditions in the Rocky Mountain Region, 1990. USDA Forest Service Renewable Resources, Forest Pest Management, Rocky Mountain Region, Lakewood, CO.

Martin, R.E.; Sapsis, D.B. 1991. Fires as agents of biodiversity: Pyrodiversity promotes biodiversity. IN: Proceedings of the Symposium on biodiversity of Northwestern California. University of California, Department of Forestry and Resource Management, Berkeley, CA.

Mason, D.T. 1915. The life history of lodgepole pine in the the Rocky Mountains. USDA Bulletin 154 pages 1-35 Washington, D.C.

McCahon, T.J.; Munn, L.C. 1991. Early and middle Pleistocene paleosols in the Medicine Bow Mountains, Wyoming. Soil Science 152(6): 472-484.

McCambridge, W.F.; Hawksworth, F.G.; Edminster, C.B.; Laut, J.G. 1982. Ponderosa pine mortality resulting from a mountain pine beetle outbreak. USDA Forest Service Research Paper RM-235 Fort Collins, CO.

McKnight, M.E. 1960a. List of unpublished reports, Fort Collins Forest Insect Laboratory 1935-1953. RMFRES Library Fort Collins, CO.

McKnight, M.E. 1960b. List of unpublished reports, Fort Collins Forest Insect Laboratory 1964-1960. RMFRES Library Fort Collins, CO.

Mears, B., Jr. 1953. Quaternary features of the Medicine Bow Mountains, Wyoming. p. 81-84. IN: Guidebook for 8th annual Field Conference Wyoming Geological Association and University of Wyoming.

Mears, B., Jr. 1962. Stone nets on Medicine Bow Peak, Wyoming. Contributions to Geology 1: 48.

Medicine Bow National Forest. 1905. Report on Medicine Bow forest Reserve. Medicine Bow Collection American Heritage Center, Laramie, WY.

Medicine Bow National Forest. 1990. Medicine Bow National Forest Land and Resource Management Plan Forest Plan Five-Year Review. Fiscal Years 1986-1990. Medicine Bow National Forest. Laramie, WY.

Meslow, E.C.; Maser, C.; Verner, J. 1981. Old growth forests as wildlife habitat. Proceedings of the 46th N. American Wildlife Conference. pages 329-334.

Mitchell, R.G. 1989. Mixed host strategies for mountain pine beetle control in Oregon. pages 60-63 IN: Proceedings - Symposium on the management of lodgepole pine to

minimize losses to the mountain pine beetle USDA Forest Service General Technical Report INT-262 Ogden, UT.

Moir, W.H. 1969. The lodgepole pine zone in Colorado. The American Midland Naturalist 81(1): 87-98.

Moir, W.H. 1994. Ecologist - Rocky Mountain Forest and Range Experiment Station (Personal Communication).

Moir, W.H.; Dieterich, J.H. 1988. Old-growth ponderosa pine from succession in pine-bunchgrass forests in Arizona and New Mexico. Natural Areas Journal 8(1): 17-24.

Moir, W.L.; Lee. K. 1990. Spatial analysis of tree invasions: a predictive model in a small watershed. USDA Forest Service General Technical Report RM-198:128-131 Fort Collins, CO.

Moir, W.L.; Huckaby, L.S. 1994. Displacement Ecology of trees near upper timberline. International Conference for Bear Research and Management 9(1): 1-8.

Musselman, R.C. (ed). 1994. The Glacier Lakes Ecosystem Experiments Site. USDA Forest Service General Technical Report RM-249 Fort Collins, CO.

Neelan, C.; Deboi, G; Mock, P.; Wolff, K; Clabaugh, T. 1994. Third draft literature review for the Routt National Forest to assist with the determination of the range of natural variablity. December, 1994 Routt National Forest. Steamboat Springs, Colorado.

Neiderhof, C.H.; Dunford, E.G. 1942. The effect of openings in a young lodgepole pine forest on the storage and melting of snow. Journal of Forestry 40(10): 802-805.

Noble, D.L. 1974. Natural regeneration of Engelmann spruce in clearcut openings in the central Rockies as affected by weather, aspect, seedbed and biotic factors. PhD Dissertation Colorado State University, Fort Collins, CO.

Noble, D.L.; Alexander, R.R. 1977. Environmental factors affecting natural regeneration of Engelmann spruce in the Central Rocky Mountains. Forest Science 23(4): 420-429.

Oberholzer, M. 1972. Encampment River barometer stream study pre-logging phase. Wyoming Game and Fish Commission Administrative Report project 0571-07-6901 Cheyenne, WY.

Oberholzer, M. 1980. Post-logging evaluation of Damfino Creek, Carbon County. 1977-1978. Wyoming Game and Fish Division Adminstrative Report Project 5079-07-6901. Cheyenne, WY.

Oosting, H.J; Reed, J.F. 1952. Virgin spruce-fir of the Medicine Bow Mountains, Wyoming. Ecological Monographs 22(5): 69-91.

Orde, C.J. 1993. Effects of human-induced forest fragementation on birds. Unpublished paper for course GR 5060 University of Wyoming, Laramie, WY.

Parkman, F.P. 1950. The Oregon trail. Mentor Books, New York.

Peet, R.K. 1978a. Forest vegetation of the Colorado Front Range: Patterns of species diversity Vegetatio 37: 65-78.

Peet, R.K. 1978b. Latitudinal variation in southern Rocky Mountan Forests Journal of Biogeography 5: 275-289.

Peet, R.K. 1981. Forest vegetation of the Colorado Front Range: composition and dynamics Vegetatio 45: 3-75.

Pfister, R.D.; Daubenmire, R. 1975. Ecology of lodgepole pine, *Pinus contorta* Dougl. IN: Management of Lodgepole Pine Ecosystems Symposium Proceedings Washington State University Cooperative Extension Service Pullman, WA..

Preisler, H.K.; Mitchell, R.G. 1993. Colonization patterns of the mountain pine beetle in thinned and unthinned lodgepole pine stands. Forest Science 39(3): 528-545.

Raphael, M.G. 1987. The Coon Creek wildlife project: effects of water yield augmentation on wildlife. IN: Management of Subalpine Forests: Building on 50 Years of Research. USDA Forest Service General Technical Report RM-149. Fort Collins, CO.

Raphael, M.G. 1988. Habitat associations of small mammals in a subalpine forest, southeastern Wyoming. IN: Management of Amphibians, Reptiles and Small Mammals in North America. USDA Forest Service General Technical Report RM-166. Fort Collins, CO.

Ray, L.L. 1940. Glacial chronology of the southern Rocky Mountains, Wyoming. Bulletin Geological Society of America 51: 1851-1918.

Reed, R.A.; Johnson-Barnard, J.; Baker, W.L. 1996. Fragmentation of a Forested Rocky Mountain Landscape 1950-1993. Biological Conservation 75:267-277.

Reed, R.A.; Johnson-Barnard, J.; Baker, W.L. In review 1995. The contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology.

Reese, R.A.; Ratti, J.T. 1988. Edge effect: A concept under scrutiny. Transactions of the 53rd North American Wildlife and Natural Resources Conference 53: 127-136.

Regelin, W.L.; Wallmo, O.C. 1978. Duration of deer forage benefits after clearcut logging of subalpine forest in Colorado. USDA Forest Service Research Note RM-356. Fort Collins, CO.

Renkin, R.A.; Despain, D.G. 1991. Fuel moisture, forest type, and lightning-caused fire in Yellowstone National Park. Canadian Journal of Forest Research 22: 37-45.

Ripple, W.A.; Bradshaw, G.A; Spies, T.A. 1991. Measuring forest landscape patterns in the Cascade Region of Oregon, USA. Biological Conservation 57: 73-88.

Romme. W.H. 1977. Vegetation in relation to elevation, topography, and fire history in a Wyoming montane watershed. Master's Thesis. University of Wyoming. Laramie, WY.

Romme, W.H. 1980. Fire frequency in subalpine forests of Yellowstone National Park. IN: Proc of the Fire History Workshop USDA Forest Service General Technical Report RM-81 Fort Collins, CO.

Romme, W.H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs 52: 199-201.

Romme, W. H.; Knight, D.H. 1981. Fire frequency and subalpine forest succession along a topographic gradient in Wyoming. Ecology 62(2): 319-326.

Romme, W.H.; Knight, D.H. 1982. Landscape diversity: the concept applied to Yellowstone Park. Bioscience 32: 664-670.

Romme, W.H. and D.G. Despain. 1989. Historical perspectives on the Yellowstone Fires of 1988. Bioscience 39(10): 695-699.

Romme, W.H.; Floyd-Hanna, L.; Hanna, D.; Grissino-Mayer, H. 1994. Presettlement range of natural variation in disturbance history and stand structure of ponderosa pine and mixed conifer forests on the San Juan National Forest Draft unpublished progress report for first year's work Contract with USFS Durango, CO.

Ronco, F. 1970. Engelmann spruce seed dispersal and seedling establishment in clearcut forest openings in Colorado - a progress report. USDA Forest Service Research Note RM-168 Fort Collins, CO.

Rose, F. 1976. Lichenological indicators of age and environmental continuity in woodlands. pp. 279-307 IN: Brown, D.H. et al. (eds.). Lichenology: Progress and Problems. New York.

Ruggiero, L.F.; Gluesing, E.A. 1981. Integrating ecological diversity requirements for wildlife habitat into forest management planning. IN: In-place resource inventories:

Principles and Practices, Proceedings of a National Workshop, Orono, ME. Society of American Foresters.

Saunders, D.A.; Hobbs, R.J; Margules, C.R. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32.

Savage, M. 1991. Structural dynamics of a southwestern pine forest under chronic human influence. Annals of the Association of American Geographers 81(2):271-289.

Schmid, J.M. 1995. Personal communication. RMFRES Entomologist - retired.

Schmid, J.M.; Amman, G.D. 1992. *Dendroctonus* beetles and old growth forests in the Rockies. pages 51-59 IN: Old Growth Forests in the southwest and Rocky Mountain Regions Proceedings of a Workshop USDA Forest Service General Technical Report RM-213. Fort Collins, CO.

Schmid, J.M.; Hinds, T.E. 1974. Development of spruce-fir stands following spruce beetle outbreak. USDA Forest Service Research Paper RM-131 Fort Collins, CO.

Scott, V.E. and G.L. Crouch. 1988. Breeding birds and small mamals in pole-sized lodgepole pine and small inclusions of aspen in Central Colorado. USDA Forest Service Research Note RM-482. Fort Collins, CO.

Scott, V.E.; Crouch, G.L; Whelan, J.A. 1982. Responses of birds and small mammals to clearcutting in a subalpine forest in central Colorado. USDA Forst Service Research Note RM-422. Fort Collins, CO.

Selva, S.B. 1994. Lichen diversity and stand continuity in the northern hardwoods and spruce-fir forests of Northern New England and Western New Brunswic., The Bryologist 97(4): 424-429.

Severson, K.E. 1963. A description and classification, by composition of the aspen stands in the Sierra Madre Mountains, Wyoming. Master's Thesis Universtiy of Wyoming.

Shepperd, W.D. 1990. A classification of quaking aspen in the Central Rocky Mountains based on growth and stand characteristics. Western Journal of Applied Forestry 5(3): 69-75

Smith, D.R. 1969. Vegetation, soils and their interrelationships at timberline in the Medicine Bow Mountains, Wyoming. Wyoming Agricultural Experiment Station Monograph #17. Laramie, WY.

Smith, K.C. 1980. Nongame birds of the Rocky Mountain spruce-fir forests and their management. IN: Management pf western forests and grasslands for nongame birds. USDA Forest Service General Technical Report INT-86. Ogden, UT.

Sobczak, C.M. 1987. An evaluation of ponderosa pine old growth in southeastern Wyoming. Master's Thesis Colorado State University
Fort Collins, CO.

Squires, J. personal communication. 1995. Rocky Mountain Forest and Range Experiment Station, Laramie, WY.

Stahelin, R. 1943. Factors influencing the natural restocking of high altitude burns by coniferous trees in the Central Rocky Mountains Ecology 24(1): 19-30.

Swetnam, T.; Brown, P.N. 1992. Oldest known conifers in the Southwestern United States: temporal and spatial patterns of maximum age. IN: Old growth forests in the southwest and Rocky Mountain Regions- Proceedings of a Workshop. USDA Forest Service General Technical Report RM-213 Fort Collins, CO.

Thilenius, J.F. 1970. A review of ecological studies in the alpine tundra and subalpine grasslands of the Medicine Bow Mountains. Unpublished manuscript. RMFRES Library Fort Collins, CO.

Thilenius, J.F. 1975. Alpine range management in the Western United States: principles, practices and problems - The status of our knowledge. USDA Forest Service Research Paper RM-157 Fort Collins, CO.

Thomas, J.W. 1979. Wildlife habitats in managed forests - the Blue Mountains of Oregon and Washington. USDA Forest Service Agriculture Handbook No. 553. Washington, D.C.

Thomas, J.W. 1987. Do we know enough to manage subalpine wildlife habitats? -- It all depends.IN: Management of subalpine forests: Building on 50 years of research. USDA Forest Service General Technical Report RM-149 Fort Collins, CO.

Thomas, J.W.; Crouch,G.L.; Bumstead, R.S; Bryant, L.D. 1975. Silvicultural options and habitat values in coniferous forests. USDA Forest Service GTR WO-1: Proceedings of the Symposium on Management of Forest and Range Habitats for non-game birds. Washington, D.C.

Thomas, J.W.; Maser, C. (eds.). 1986. Wildlife habitats in managed rangelands - the Great Basin of southeastern Oregon. USDA Forest Service, USDA BLM. Series of General Technical Reports Pacific Northwest Research Station 1979-1985.

Tinker, D.; Romme, W.H.; Hargrove, W.W.; Gardner, R.H.; Turner, M.G. 1994. Landscape scale heterogeneity in lodgepole pine serotiny. Canadian Journal of Forest Research. 24: 897-903.

Tinnen, R.O.; Hawksworth, F.G.; Knutson, D.J. 1982. Witches brooms formation in conifers infected by *Arceuthobium* spp.; an example of parasitic impact upon community dynamics American Midland Naturalist. 107: 351-259.

Tinnen, R.O. 1984. The effect of dwarf-mistletoe on forest community ecology. Biology of dwarf mistletoes: Proceedings of the symposium pages 117-122 USDA Forest Service General Technical Report. RM-111 Fort Collins, CO.

Troendle, C.A. 1995. Personal communication. RMFRES - Hydrology Group Leader.

Troendle, C.A.; Kaufmann, M.R. 1987. Influence of forests on the hydrology of the subalpine forest. IN: Troendle et al. Management of subalpine forests: Building on 50 years of research. USDA Forest Service General Technical Report RM-149 Fort Collins, CO.

Turner, G.Y.; Paulsen, H.A Jr. 1976. Management of mountain grasslands in the Central Rockies: The status of our knowledge. USDA Forest Service. RM-161 Fort Collins, CO.

Turner, M.G.; Romme, W.H. 1993. Landscape dynamics in crown fire ecosystems. In Press Landscape Ecology.

USDA Forest Service. 1993. III. Affected Environment page III-24 IN: Deep Creek, Strawberry Gulch Timber Sale Environmental Assessment. Hayden Ranger District Medicine Bow National Forest. Laramie, WY.

Veblen, T.T. and D.C. Lorenz. 1986. Anthropogenic disturbance and recovery patterns in montane forests, Colorado, Front Range. Physical Geography 7(1):1-24.

Veblen, T.T.; Hadley, K.S.; Reid, M.S.; Rebertus, A.J. 1989. Blowdown and stand development in a Colorado subalpine forest. Canadian Journal of Forest Research. 19:1218-1225.

Veblen, T.T.; Lorenz, D.C. 1991. The Colorado Front Range: A century of ecological change. University of Utah Press Salt Lake City, Utah.

Veblen, T.T.; Hadley,, K.S.; Reid, M.S.; Rebertus, A.J. 1991. The response of subalpine forests to spruce beetle outbreak in Colorado. Ecology 72(1): 213-231.

von Ahlefeldt, J. 1994. Personal field observations. Forest Ecologist, MBNF.

Wallmo, O.C. 1969. Response of deer to alternate-strip clearcutting of lodgepole pine and spruce-fir timber in Colorado. USDA Forest Service Research Note RM-141 Fort Collins, CO.

Weaver, H. 1951. Fire as an ecological factor in the southwestern ponderosa pine forests. Journal of Forestry 49: 93-98.

Weidler, B. 1995. Edaphic characteristics of four Rocky Mountain soils under lodgepole pine. Master's Thesis. University of Wyoming. (In Progress).

Wheeler, N.C.; Critchfield, W.B. 1984. The distribution and botanical characteristics of lodgepole pine: biogeographical and management implications. IN: Lodgepole pine: the species and its management Washington State University Pullmman, WA.

Whipple, S.A.; Dix. R.L. 1979. Age structure and successional dynamics of a Colorado subalpine forest. The American Midland Naturalist 101(1): 142-158.

Wilcove, D.S. 1987. From fragmentation to extinction. Natural Areas Journal 7(1): 23-29.

Wilcox, M. 1995. personal communication. Forest Hydrologist, Medicine Bow National Forest.

Williams, G.W. 1993. References on the American Indian use of fire in ecosystems Draft - USDA Forest Services Pacific Northwest Region.

Yahner, R.H. 1988. Changes in wildlife communities near edges. Conservation Biology 2: 333-339.

Zimmerman, M.L. 1995. A study of moose herbivory in willow communities in Colorado. Master's Thesis in progress. Colorado State University, Fort Collins, CO.

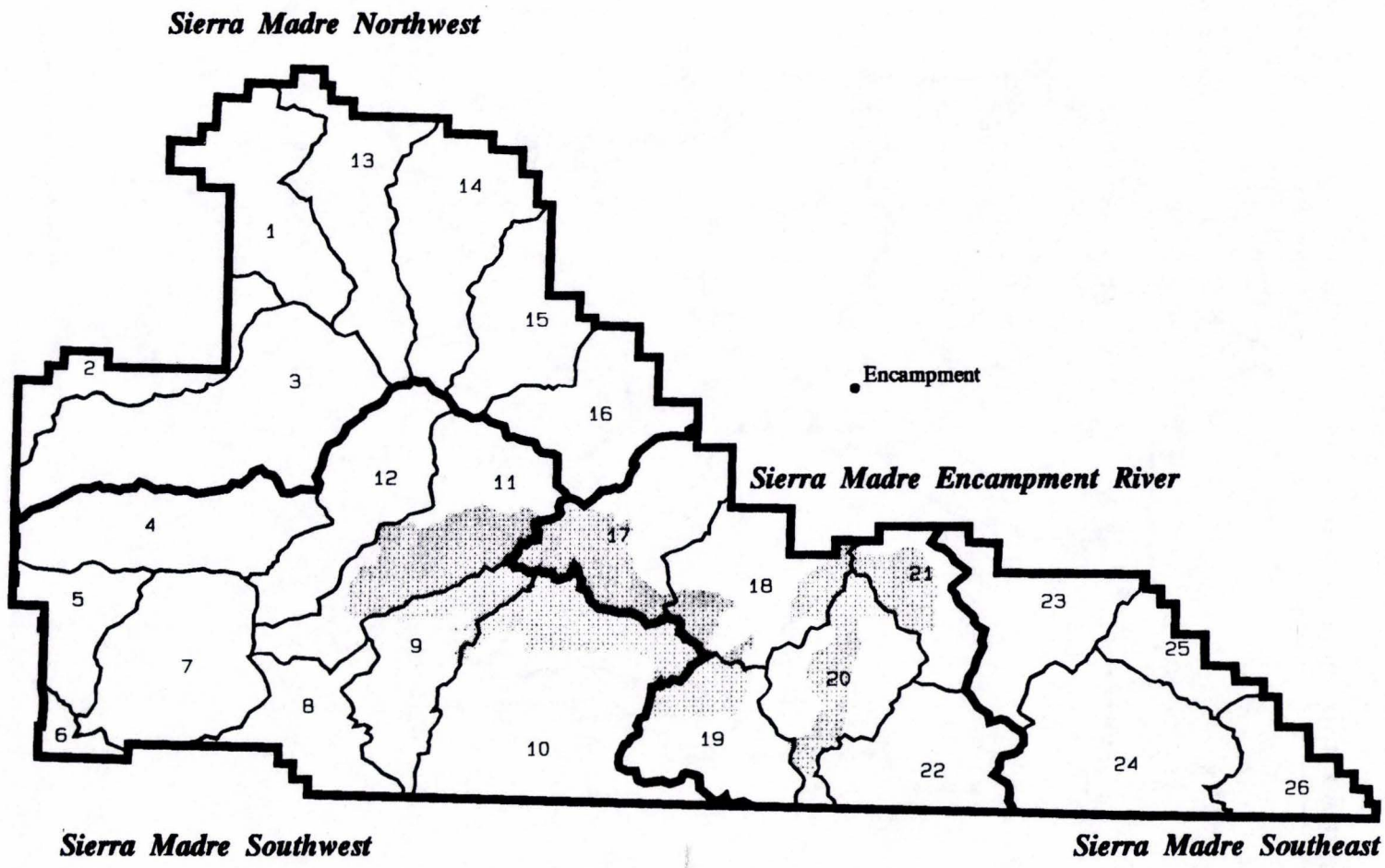
Zimmerman, G.T.; Laven, R.D. 1984. Ecological interrelationships of dwarf mistletoe and fire in lodgepole pine forests. Biology of dwarf mistletoes: Proceedings of a Symposium. USDA Forest Service General Technical Report RM-111 Fort Collins, CO.

MEDICINE BOW NATIONA[illegible]REST

SIERRA MAD[illegible]

Biodiversity Unit and Area Map

FIGURE 6.1a



LEGEND

1 Savery Creek
2 Dirtyman Creek
3 Big Sandstone Creek
4 Little Sandstone Creek
5 Big Gulch
6 E. Sweetwater Gulch
7 Lower Battle Creek
8 Cottonwood Creek
9 Roaring Fork Little Snake
10 North Fork Little Snake
11 Upper Battle Creek
12 West Fork Battle Creek
13 Jack Creek
14 North Spring Creek
15 South Spring Creek
16 Cow Creek
17 N. Fork Encampment River
18 South Fork Miner Creek
19 Hog Park Creek
20 Encampment River Canyon
21 Billie Creek
22 E. Fork Encampment River
23 Beaver Creek
24 Middle Fork Big Creek
25 Bear Creek
26 South Fork Big Creek

Biodiversity Unit Boundary

Biodiversity Area Boundary

Wilderness

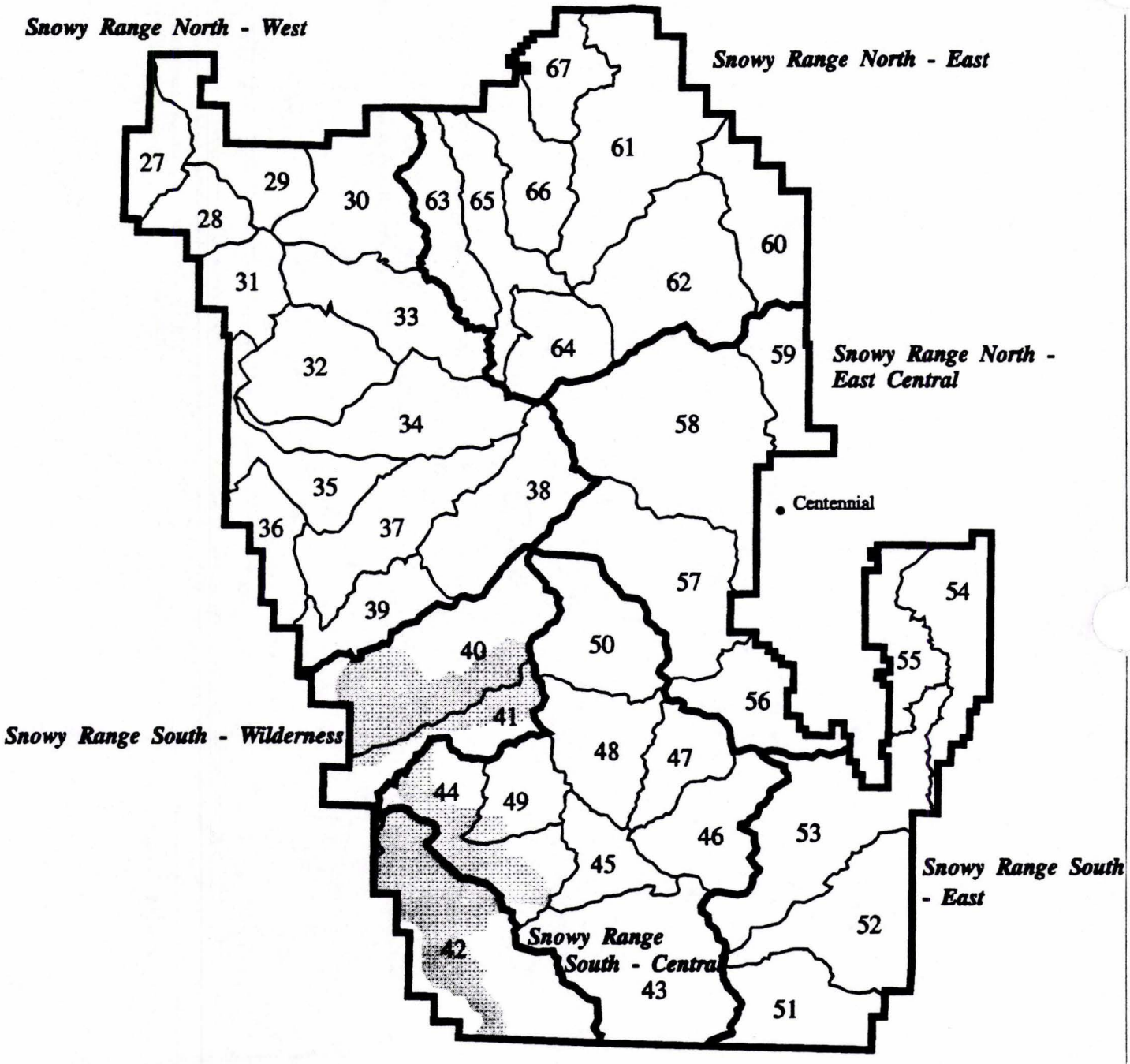
Scale 1 to 375,000

Created by CLT for JVA, 01/20/95, bdu_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Biodiversity Units and Areas

FIGURE 6.1b



Created by CLT for JVA, 01/20/95, bdu snowy.aml

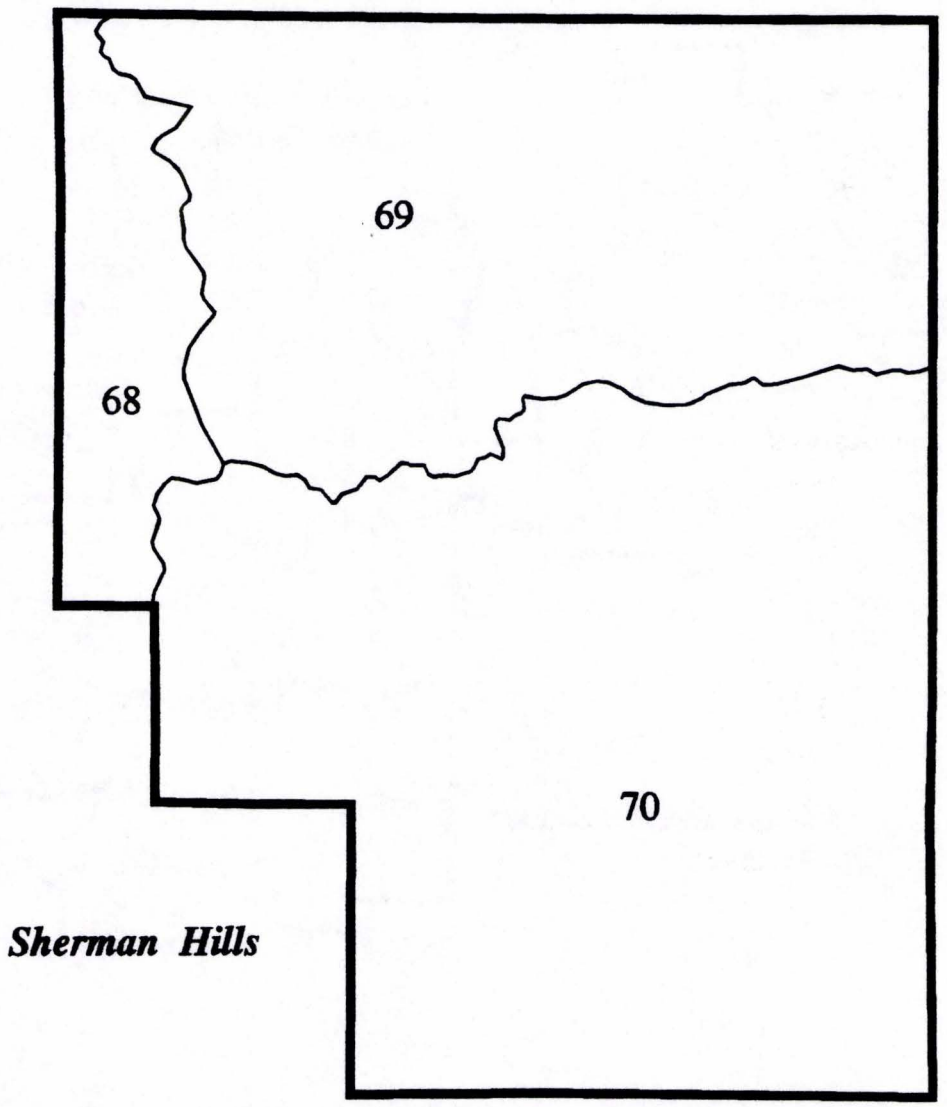
27	S. Fork Lake Creek	39	Lower South French Creek	51	Boswell Creek	63	West Medicine Bow River
28	North Cedar Creek	40	Mullen Creek	52	Bear Creek	64	Upper Medicine Bow River
29	Rankin Creek	41	Cottonwood Creek	53	Lake Owen Creek	65	Lower Medicine Bow River
30	Pass Creek	42	Platte River	54	Johns Creek	66	East Medicine Bow River
31	South Cedar Creek	43	Pelton Creek	55	Buckeye Creek	67	Wagonhound Creek
32	Lower North Brush Creek	44	Lower Douglas Creek	56	South Fork		
33	Upper North Brush Creek	45	Mowberg Creek	57	Middle Fork		Biodiversity Unit Boundary
34	South Brush Creek	46	Lake Creek	58	North Fork		Biodiversity Area Boundary
35	Lower Brush Creek	47	Muddy Creek	59	Mill Creek		Wilderness
36	North Cottonwood Creek	48	Middle Douglas Creek	60	Fourmile Creek		
37	Middle French Creek	49	Devils Gate Creek	61	North Rock Creek		
38	Upper South French Creek	50	Upper Douglas Creek	62	South Rock Creek		

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Biodiversity Units and Areas

FIGURE 6.1c



Created by CLT for JVA, 01/23/95, bdu_sherman.ami

LEGEND

68 Telephone Creek
69 Lodgepole Creek
70 Crow Creek

Biodiversity Unit Boundary

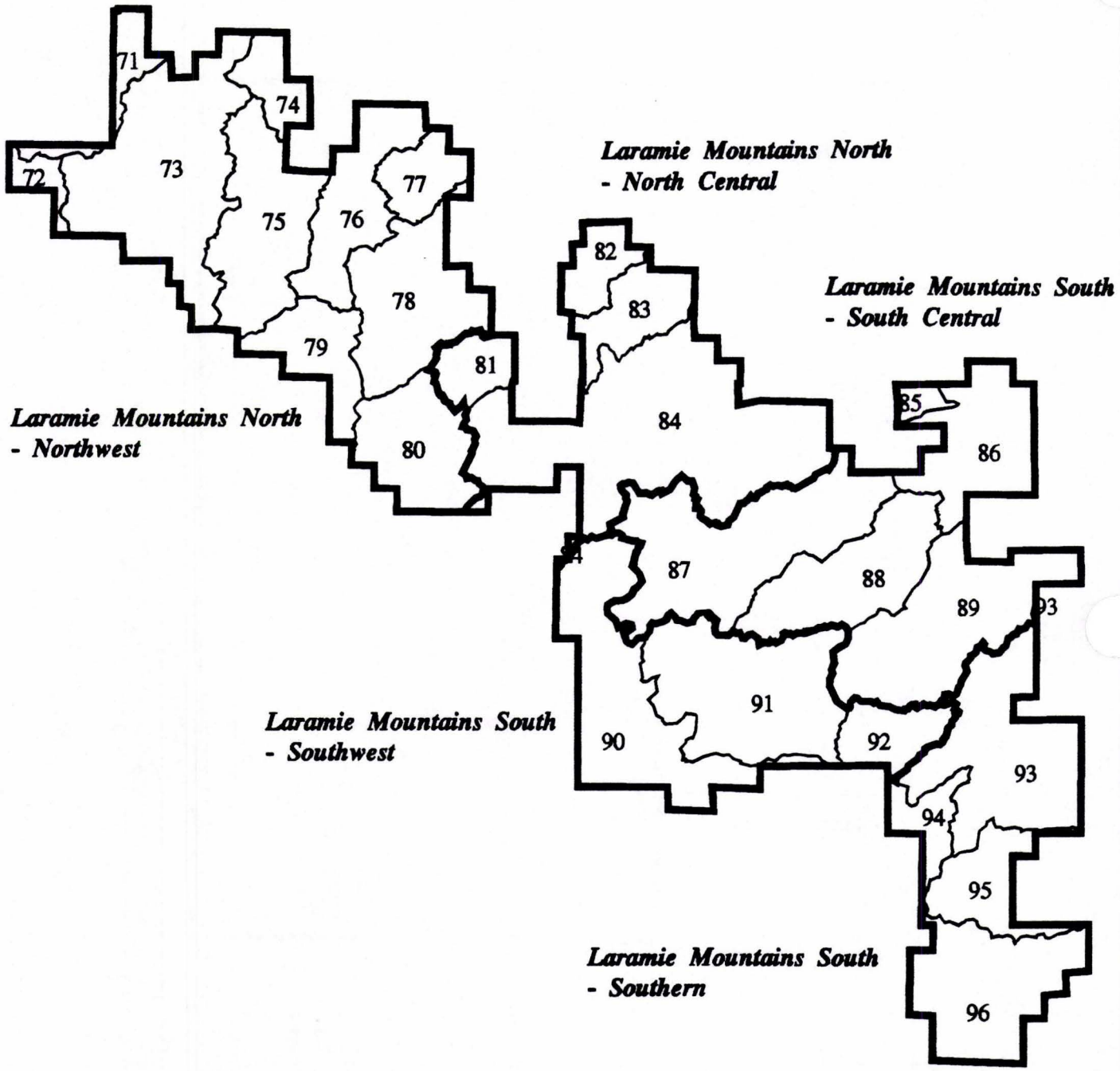
Biodiversity Area Boundary

Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST — LARAMIE RANGE

Biodiversity Units and Areas

FIGURE 6.1d



Created by CLT for JVA, 01/23/95, bdu laramie.aml

LEGEND

71 West Fork Deer Creek
72 Bates Creek
73 Upper Deer Creek
74 Virden Creek
75 Box Elder Creek
76 East Box Elder Creek
77 Standing Rock Creek
78 Meadow Creek
79 Little Medicine Bow River
80 Sheep Creek
81 Rocky Ford Creek
82 Latham Creek
83 West Fork LaBonte Creek
84 LaBonte Creek
84 LaBonte Creek
85 Mill Creek
86 Lower Horseshoe Creek
87 Upper Horseshoe Creek
88 Roaring Fork
89 Cottonwood Creek
90 Eggleston Creek
91 Bear Creek
92 North Laramie River
93 Claude Irvine Creek
93 Claude Irvine Creek
94 Owen Creek
95 Dry Laramie River
96 Luman Creek

Biodiversity Unit Boundary

Biodiversity Area Boundary

Scale 1 to 425,000

MEDICINE BOW NATIONAL FOREST

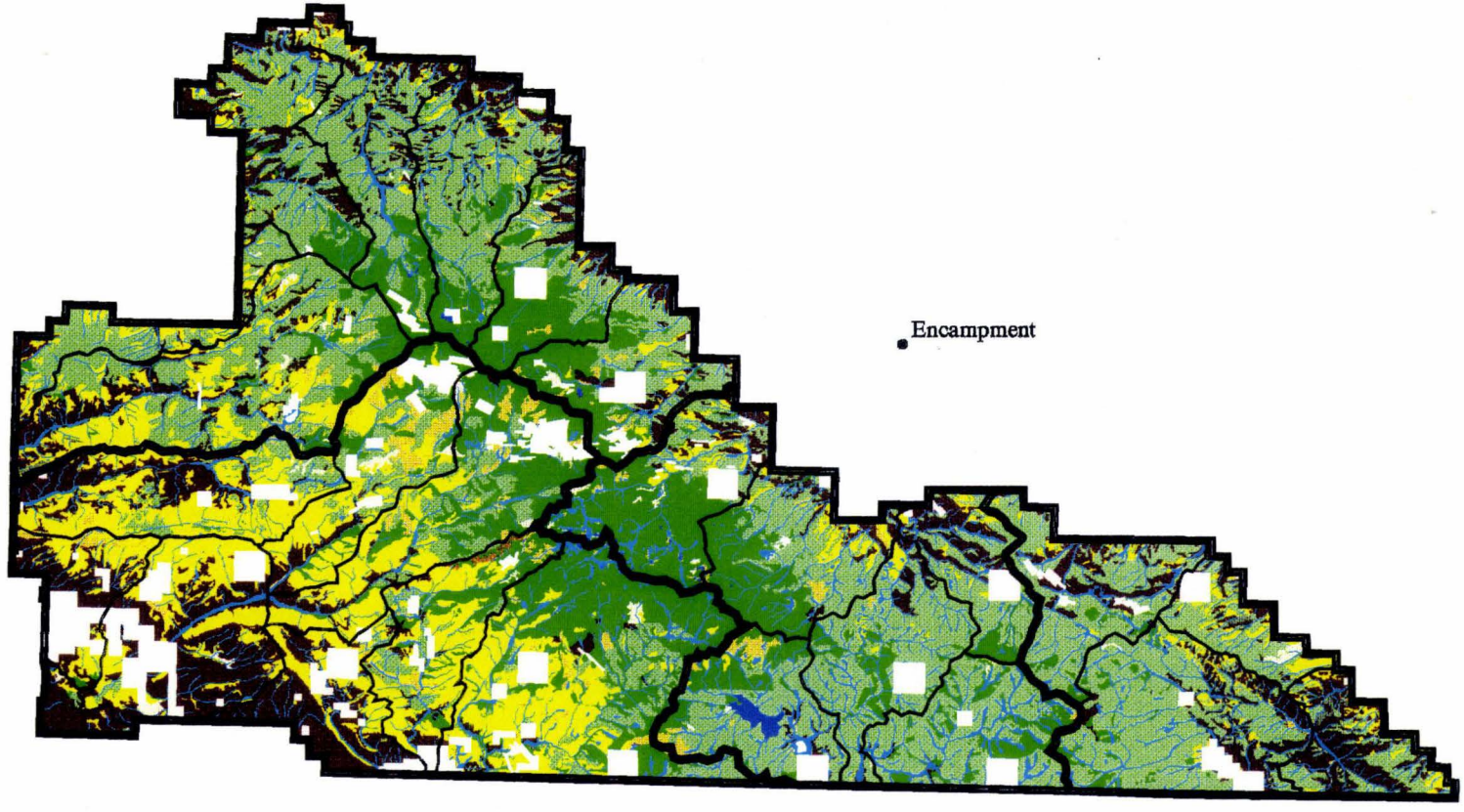
Cover Type Map

SIERRA MADRES

FIGURE 6.2a

LEGEND

- Spruce-fir forest
- Lodgepole pine forest
- Limber pine forest
- Ponderosa pine forest
- Douglas-fir forest
- Aspen forest
- Juniper woodland
- Upland shrubland
- Upland forbland
- Upland grassland
- Upland non-vegetated
- Riparian
- Water
- No data or State, Private



- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

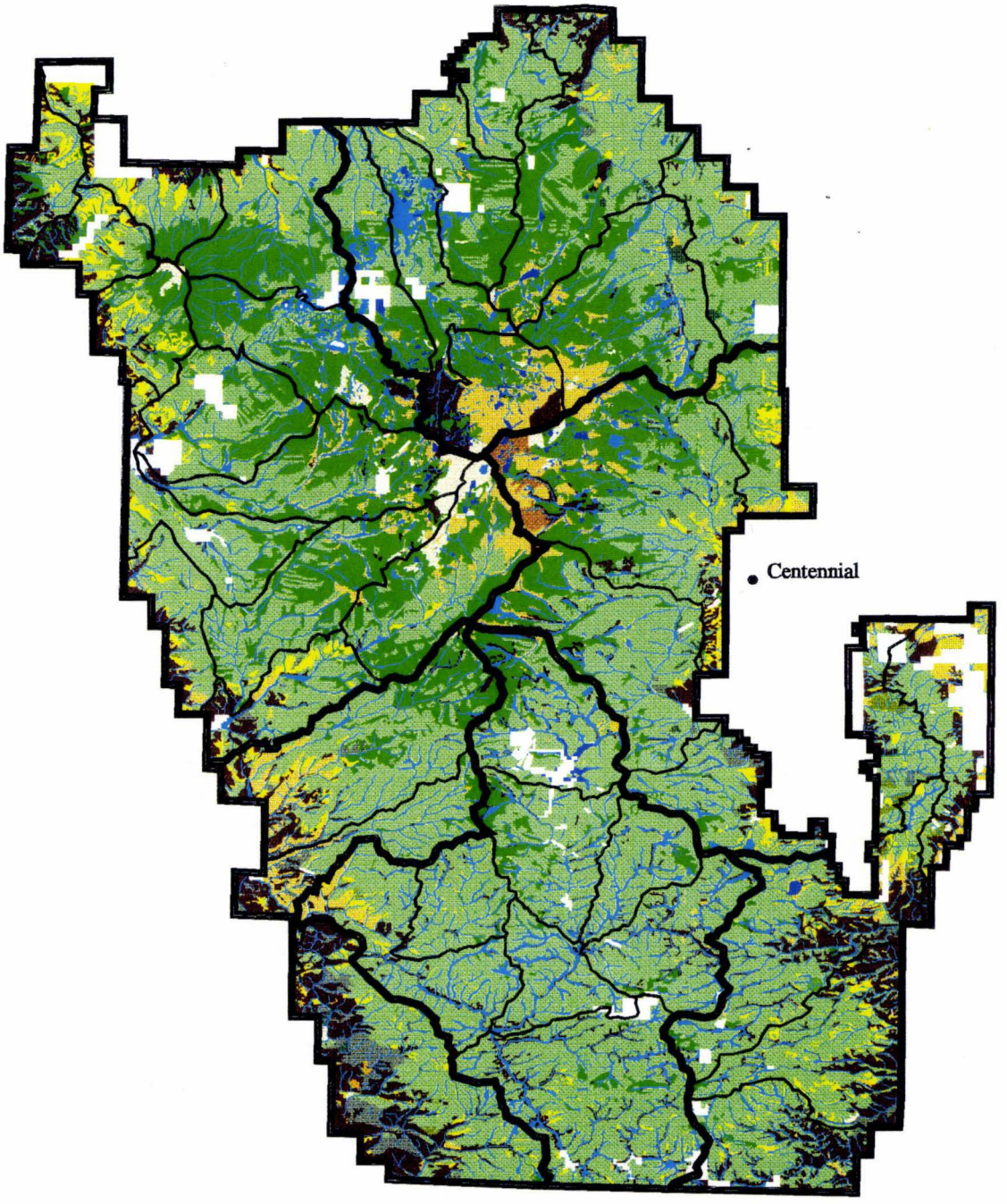
Created by CLT for JVA, 01/19/95, cov_sierra.aml

MEDICINE BOW NATIONAL FOREST

Cover Type Map

SNOWY RANGE

FIGURE 6.2b



Created by CLT for JVA, 01/19/95, cov snowy.aml

LEGEND

- Spruce-fir forest
- Lodgepole pine forest
- Limber pine forest
- Ponderosa pine forest
- Douglas-fir forest
- Aspen forest
- Juniper woodland
- Upland shrubland
- Upland forbland
- Upland grassland
- Upland non-vegetated
- Riparian
- Water
- No data or State, Private
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

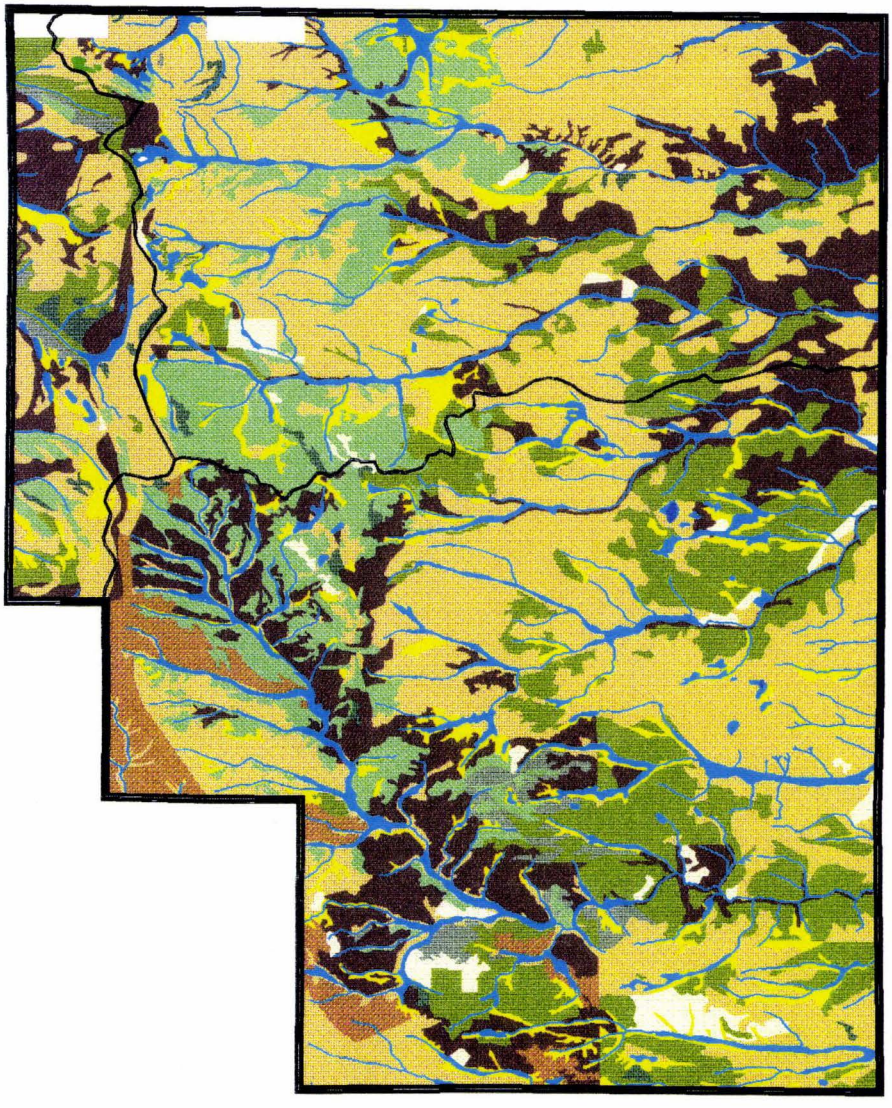
Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Cover Type Map

SHERMAN MOUNTAINS

FIGURE 6.2c



Created by CLT for JVA, 01/19/95, cov_sherman.aml

LEGEND

- Spruce-fir forest
- Lodgepole pine forest
- Limber pine forest
- Ponderosa pine forest
- Douglas-fir forest
- Aspen forest
- Juniper woodland
- Upland shrubland
- Upland forbland
- Upland grassland
- Upland non-vegetated
- Riparian
- Water
- No data or State, Private
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

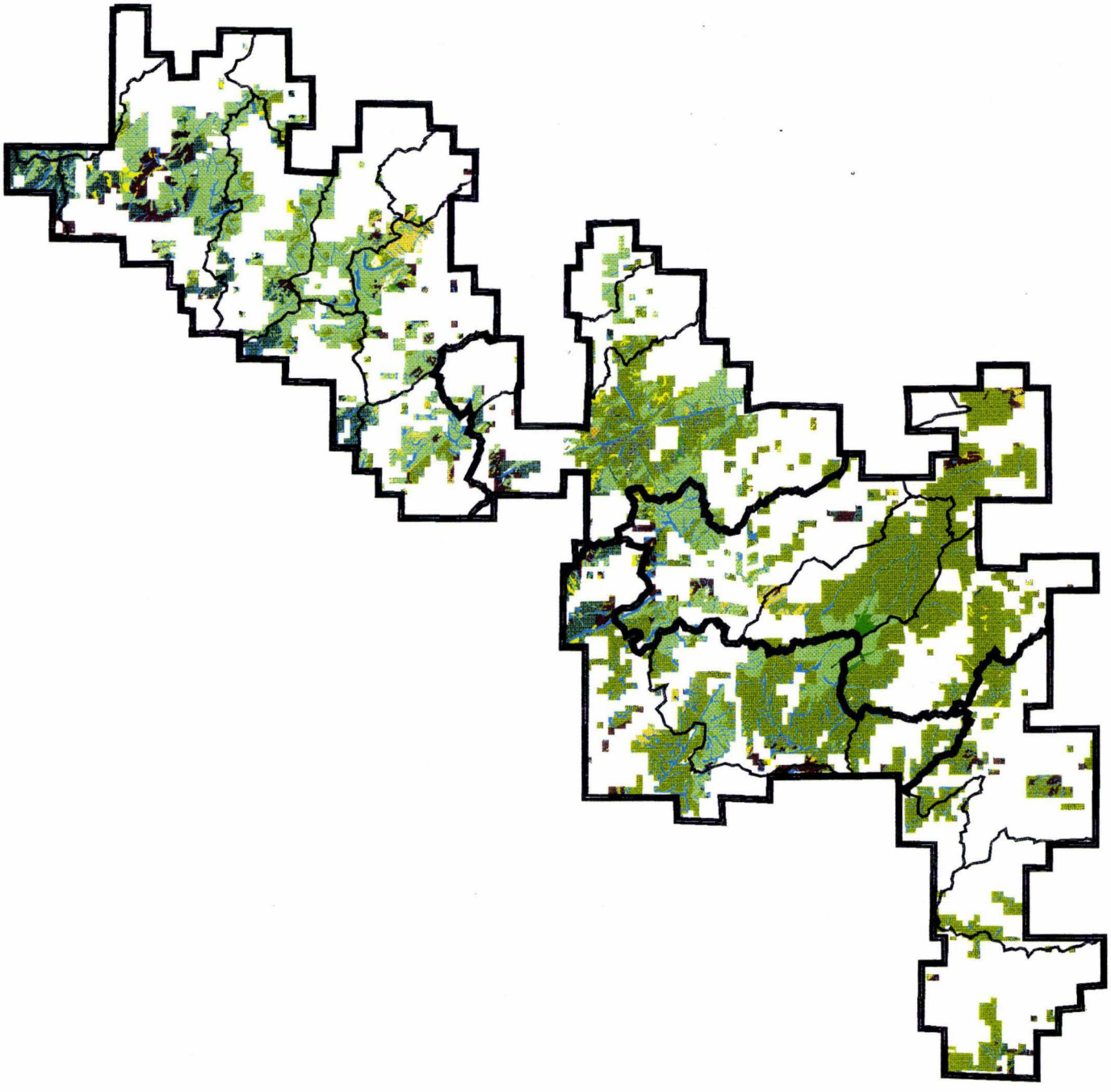
Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST

Cover Type Map

LARAMIE RANGE

FIGURE 6.2d



Created by CLT for JVA, 01/19/95, cov laramie.aml

LEGEND

- Spruce-fir forest
- Lodgepole pine forest
- Limber pine forest
- Ponderosa pine forest
- Douglas-fir forest
- Aspen forest
- Juniper woodland
- Upland shrubland
- Upland forbland
- Upland grassland
- Upland non-vegetated
- Riparian
- Water
- No data or State, Private
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 425,000

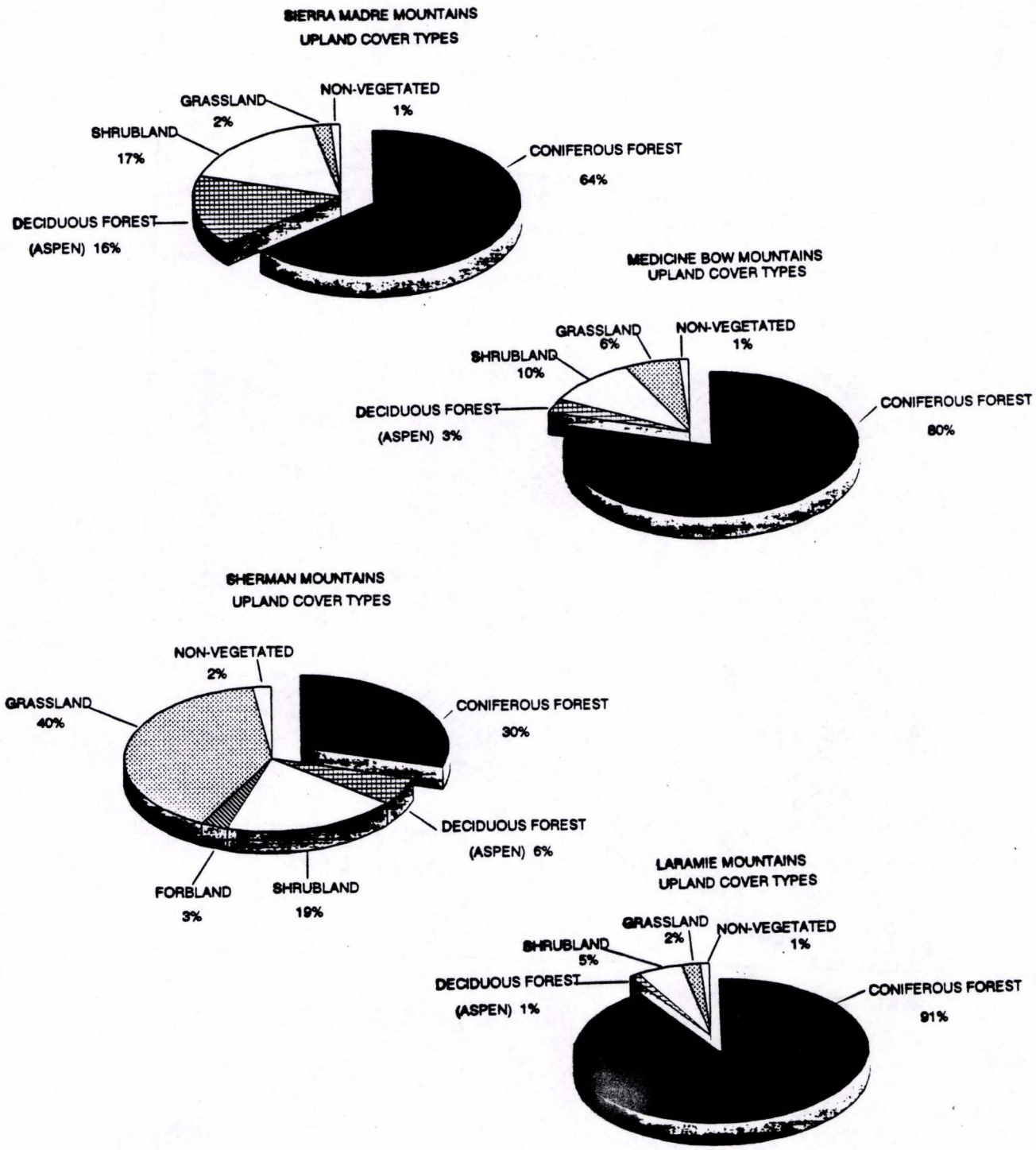


FIGURE 6.3 Diversity of major terrestrial cover types of each mountain range of the Medicine Bow National Forest.

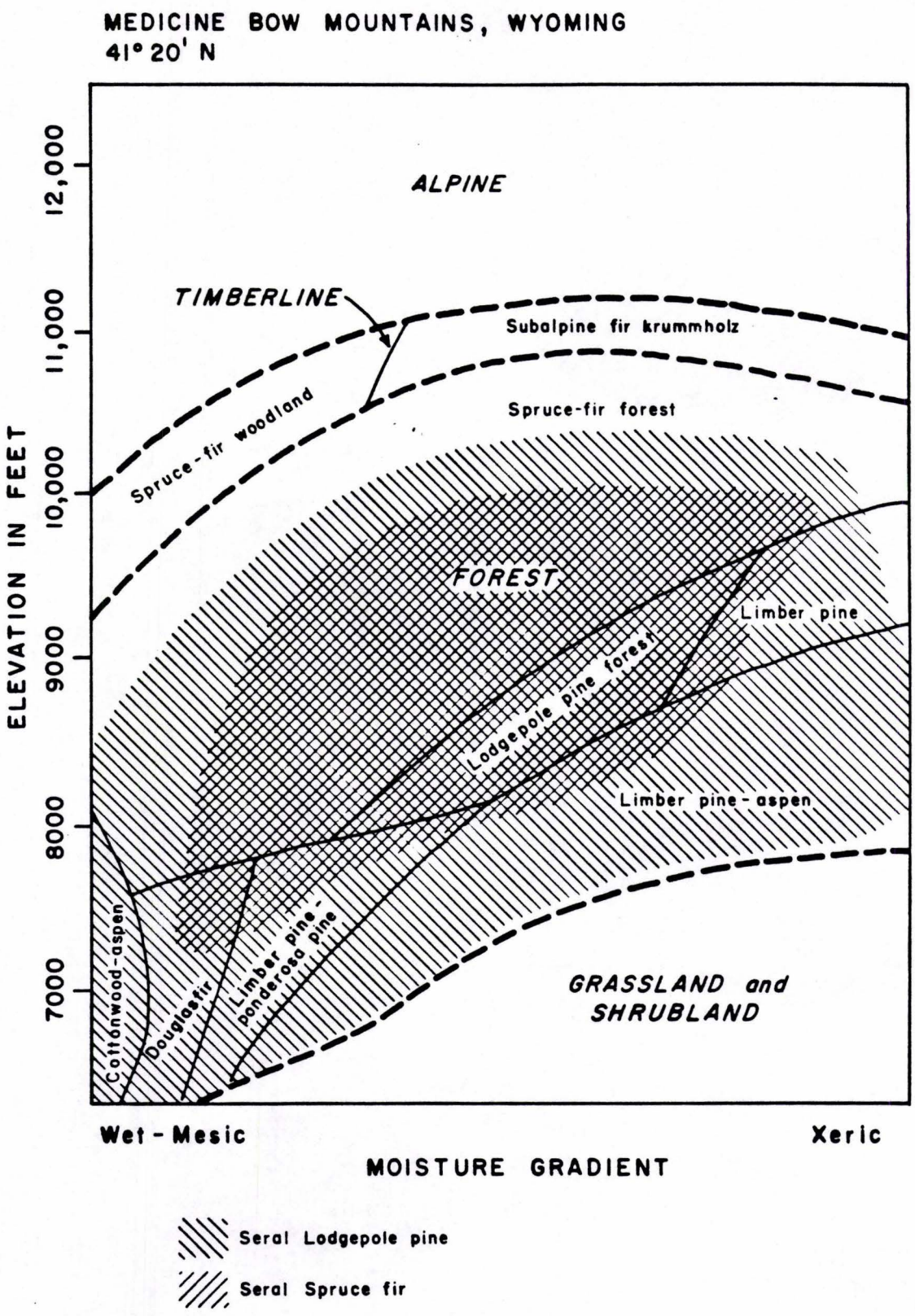


FIGURE 6.4 Community mosaic diagram showing the distribution of major vegetation series and community types for the Medicine Bow Mountains along topographic-moisture gradients. The heavy lines indicate different major types. The crosshatch area indicates seral communities, some of which overlap elevational and moisture gradient ranges of "climax" vegetation (after Peet, 1978b).

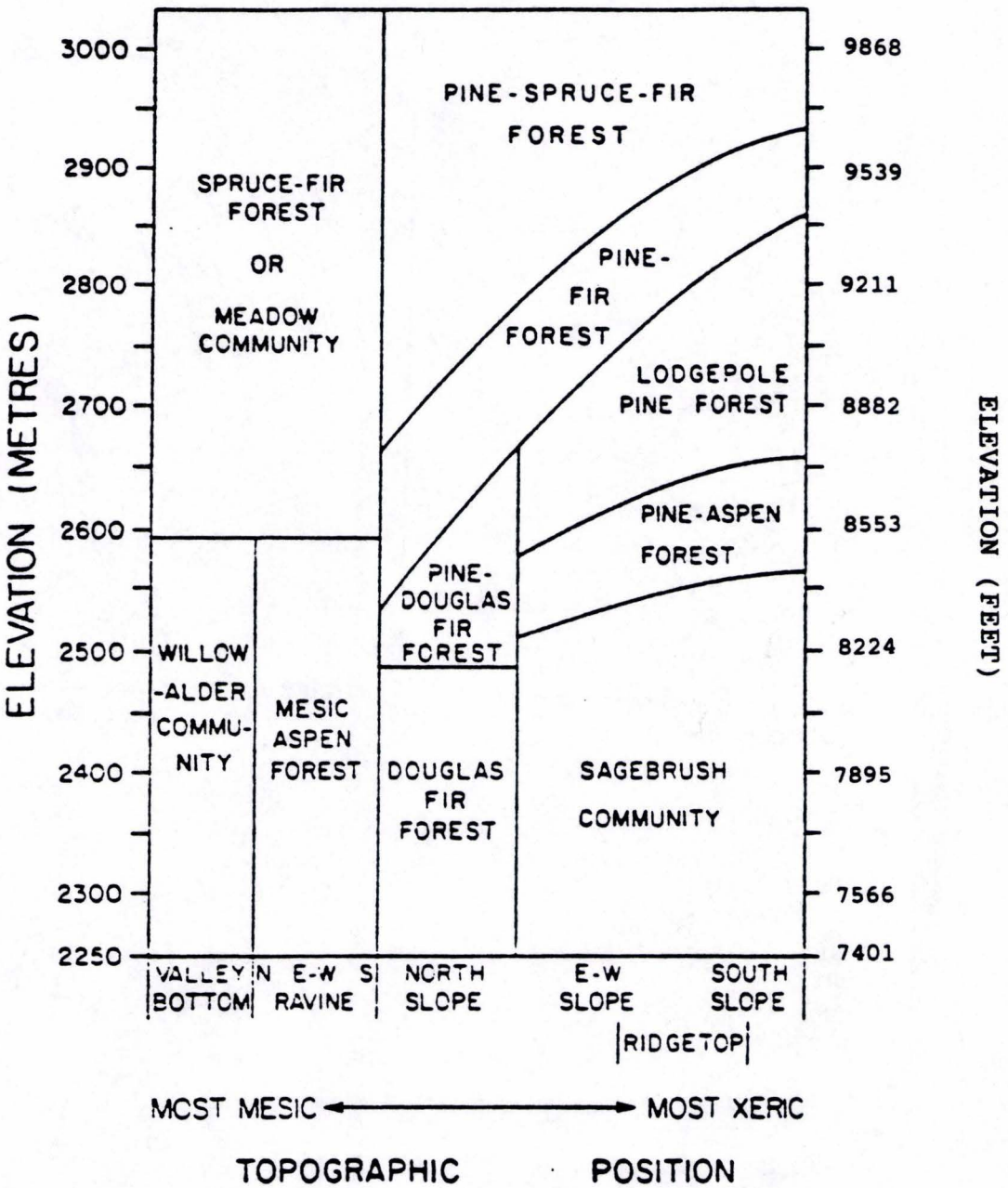


FIGURE 6.5 Community mosaic diagram for a portion of the Savage Run Wilderness area from approximately 8800 to 9800 feet (Romme and Knight, 1981). Within each of these major groups is a diversity of community types. For example, there are over a dozen kinds of understories for upland lodgepole pine forests and over a dozen and a half recognized community types associated with upland spruce-fir, spruce or fir forests on the Medicine Bow.

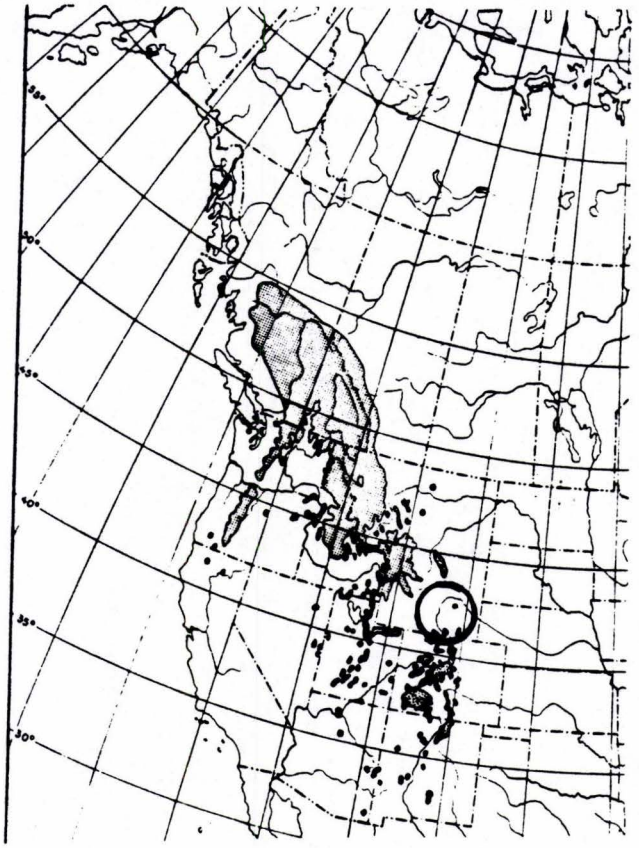


FIGURE 6.6a Range of Engelmann spruce (Little, 1971).

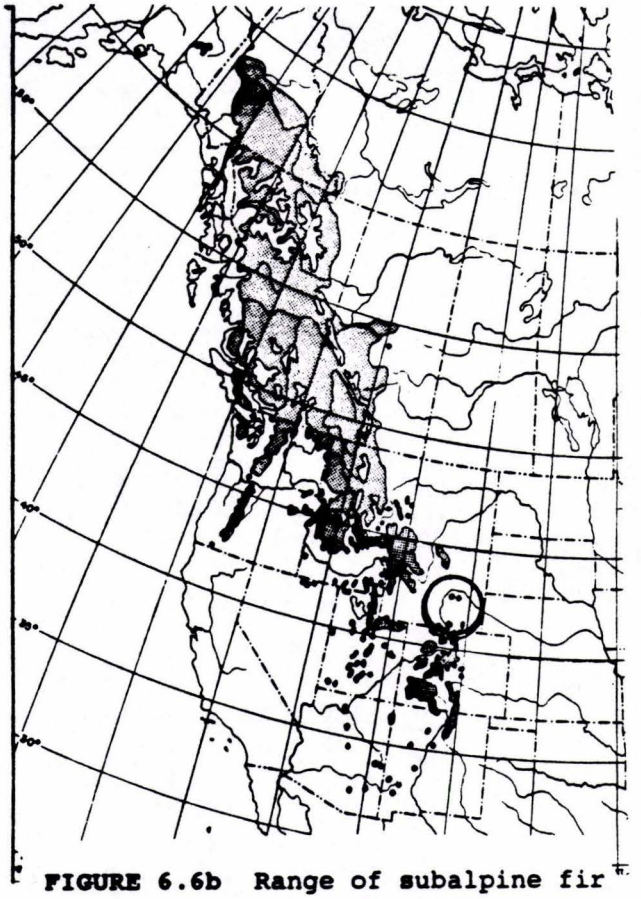


FIGURE 6.6b Range of subalpine fir (Little, 1971).

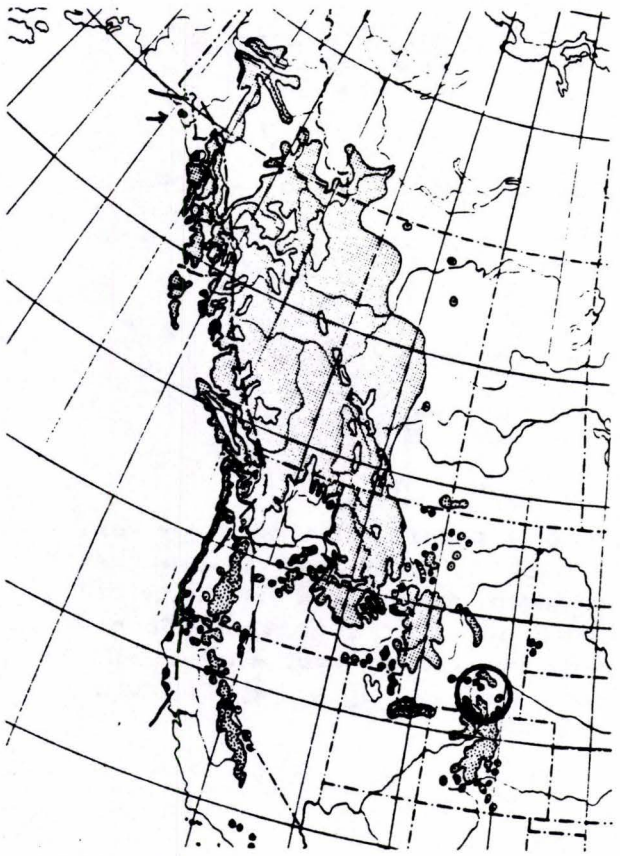


FIGURE 6.6c Range of lodgepole pine (Little, 1971).

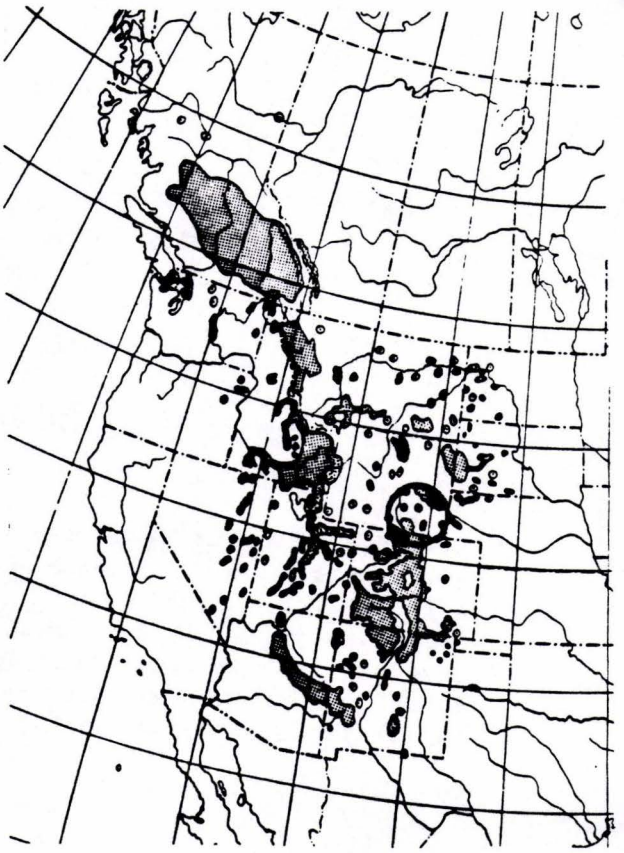


FIGURE 6.6d Range of Rocky Mountain juniper (Little, 1971).

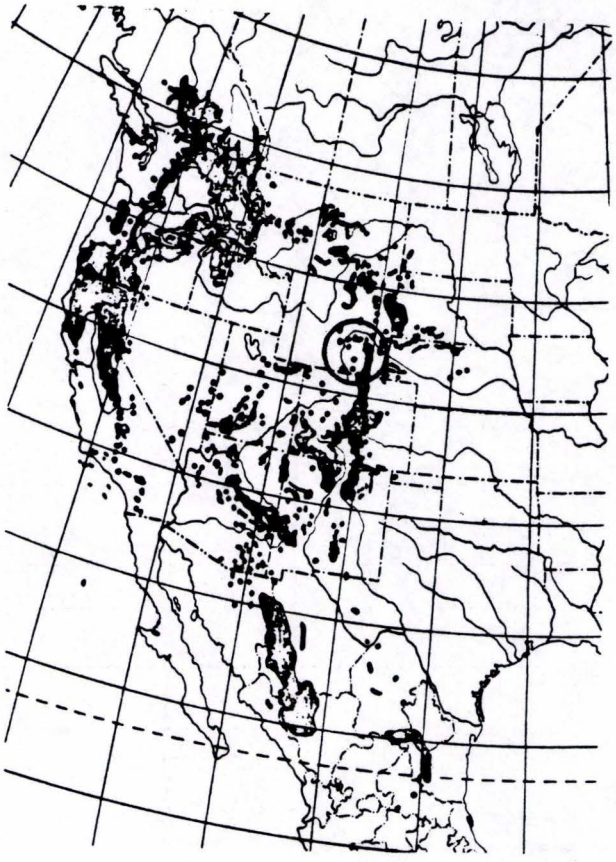


FIGURE 6.6e Range of ponderosa pine (Little, 1971).

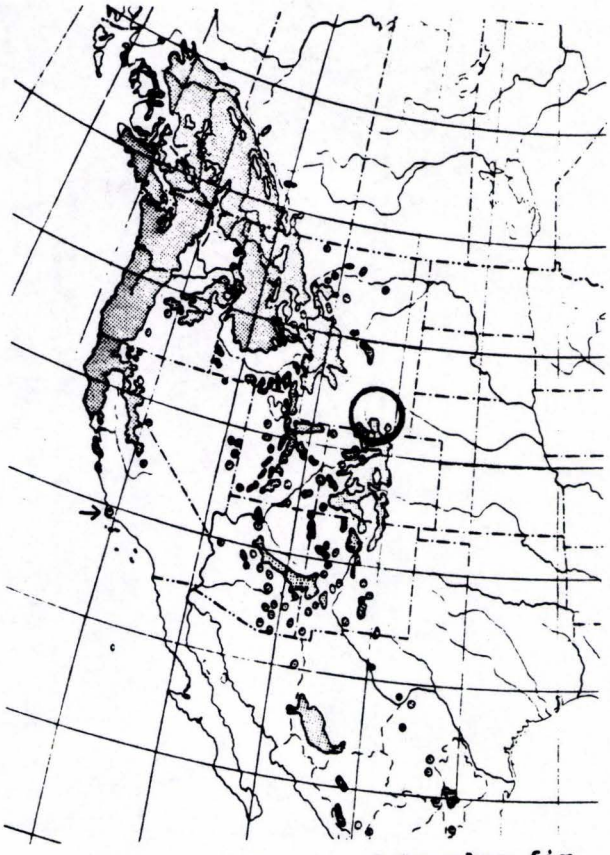


FIGURE 6.6f Range of Douglas fir (Little, 1971).

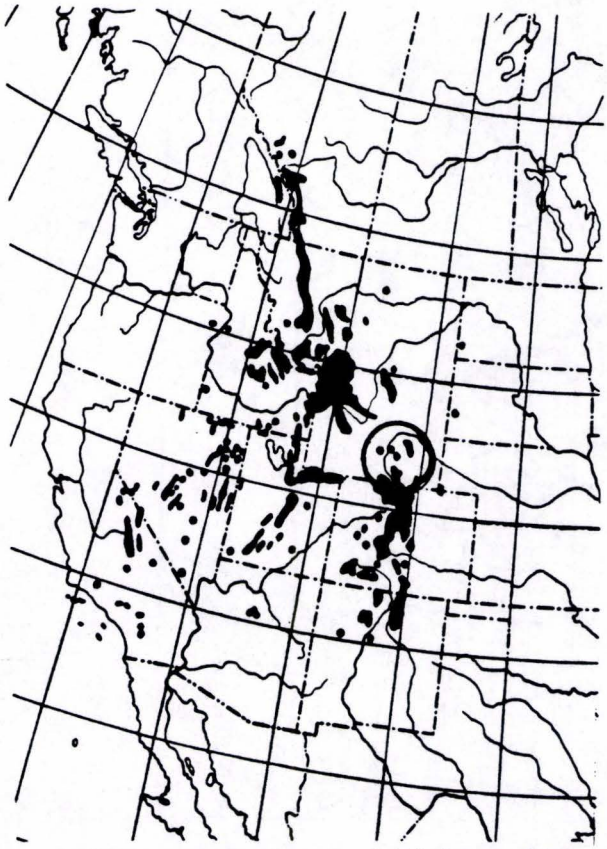


FIGURE 6.6g Range of limber pine (Little, 1971).

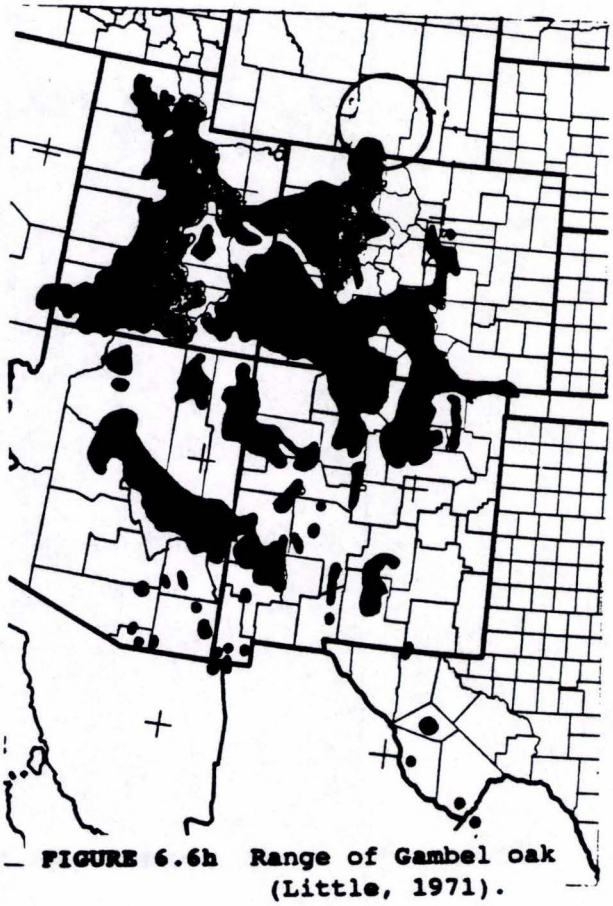


FIGURE 6.6h Range of Gambel oak (Little, 1971).

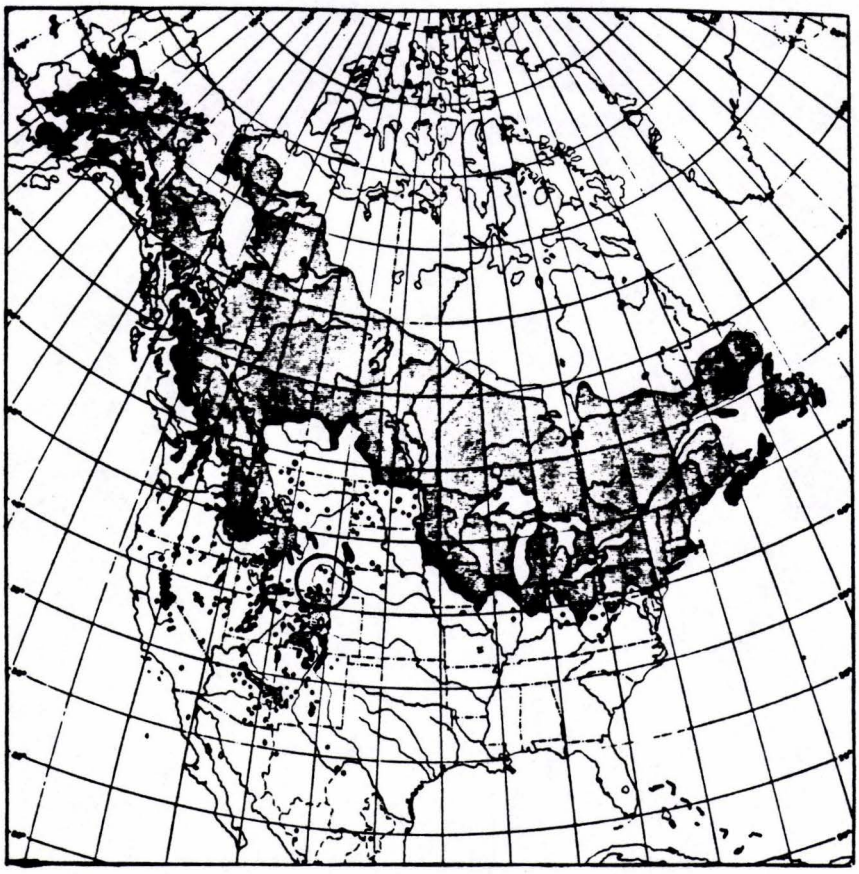


FIGURE 6.6i Range of quaking aspen (Little, 1971).

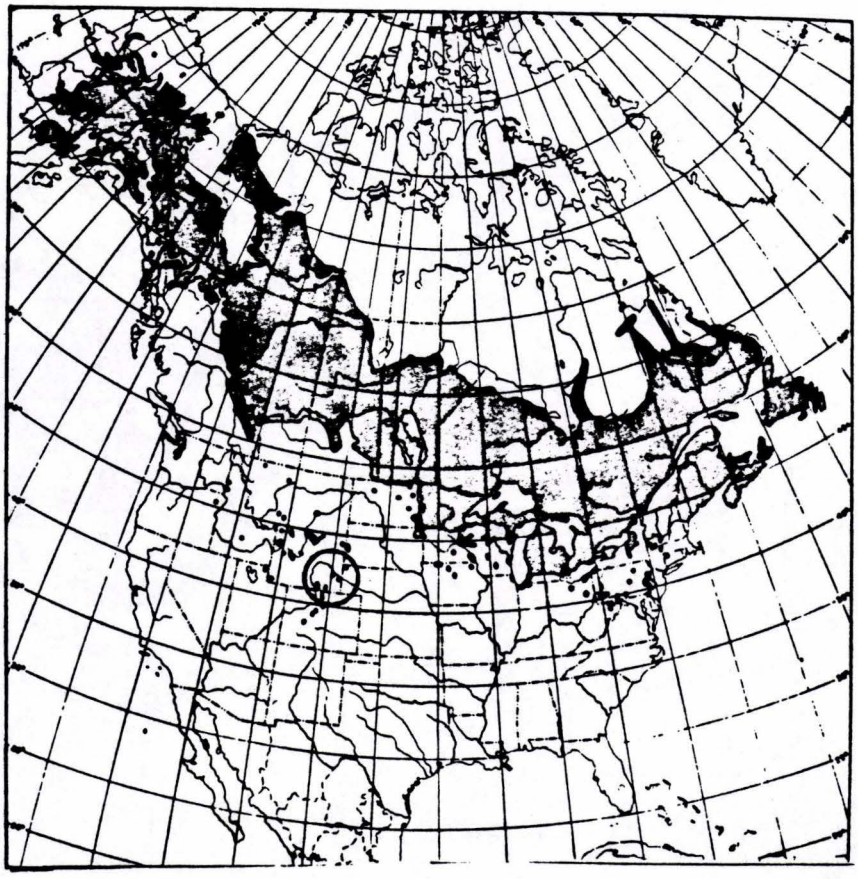


FIGURE 6.6j Range of balsam poplar (Little, 1971).

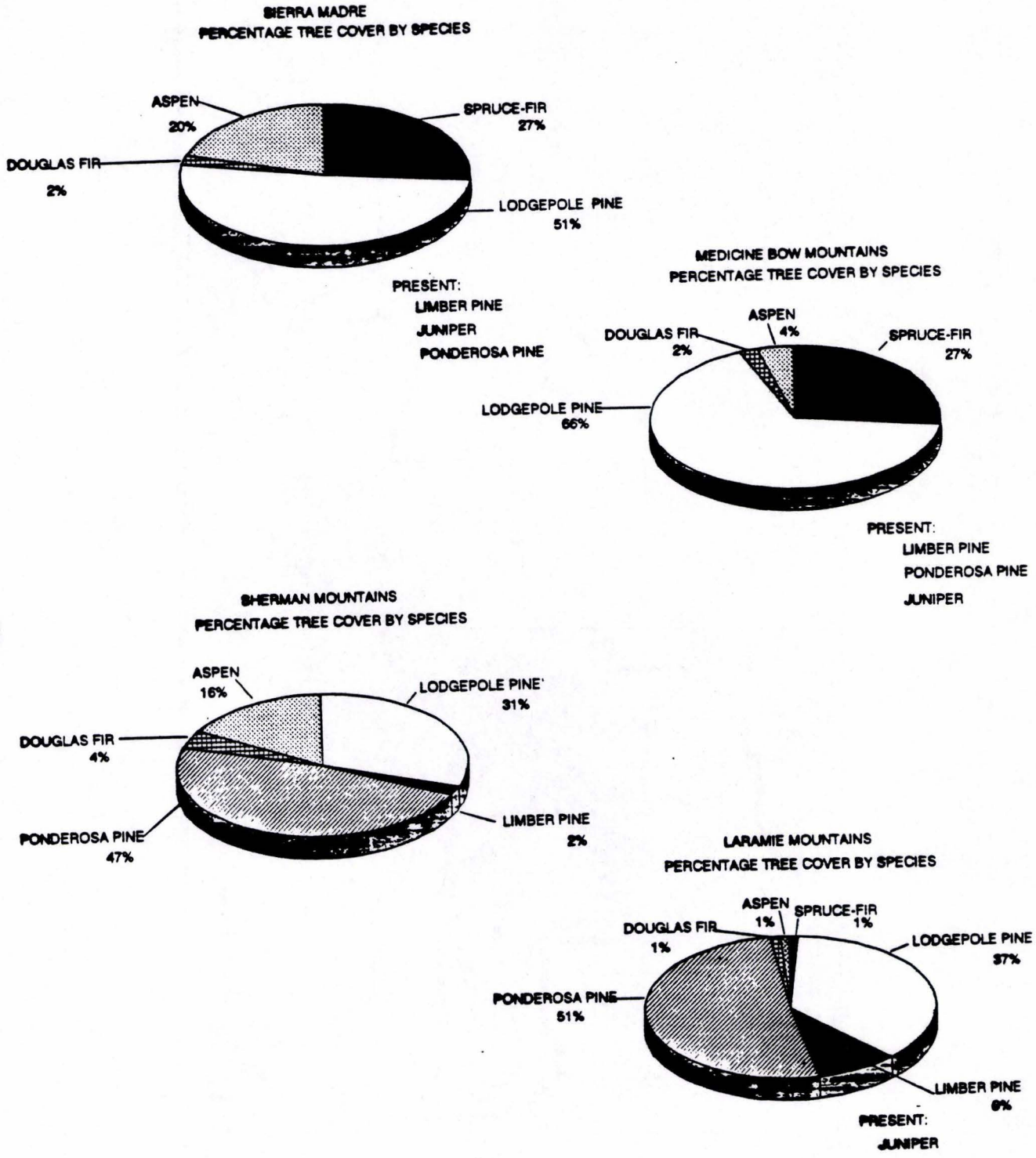


FIGURE 6.7 Forest diversity among the mountain ranges of the Medicine Bow National Forest expressed as percentage of tree cover of major forest species.

MEDICINE BOW NATIONAL FOREST

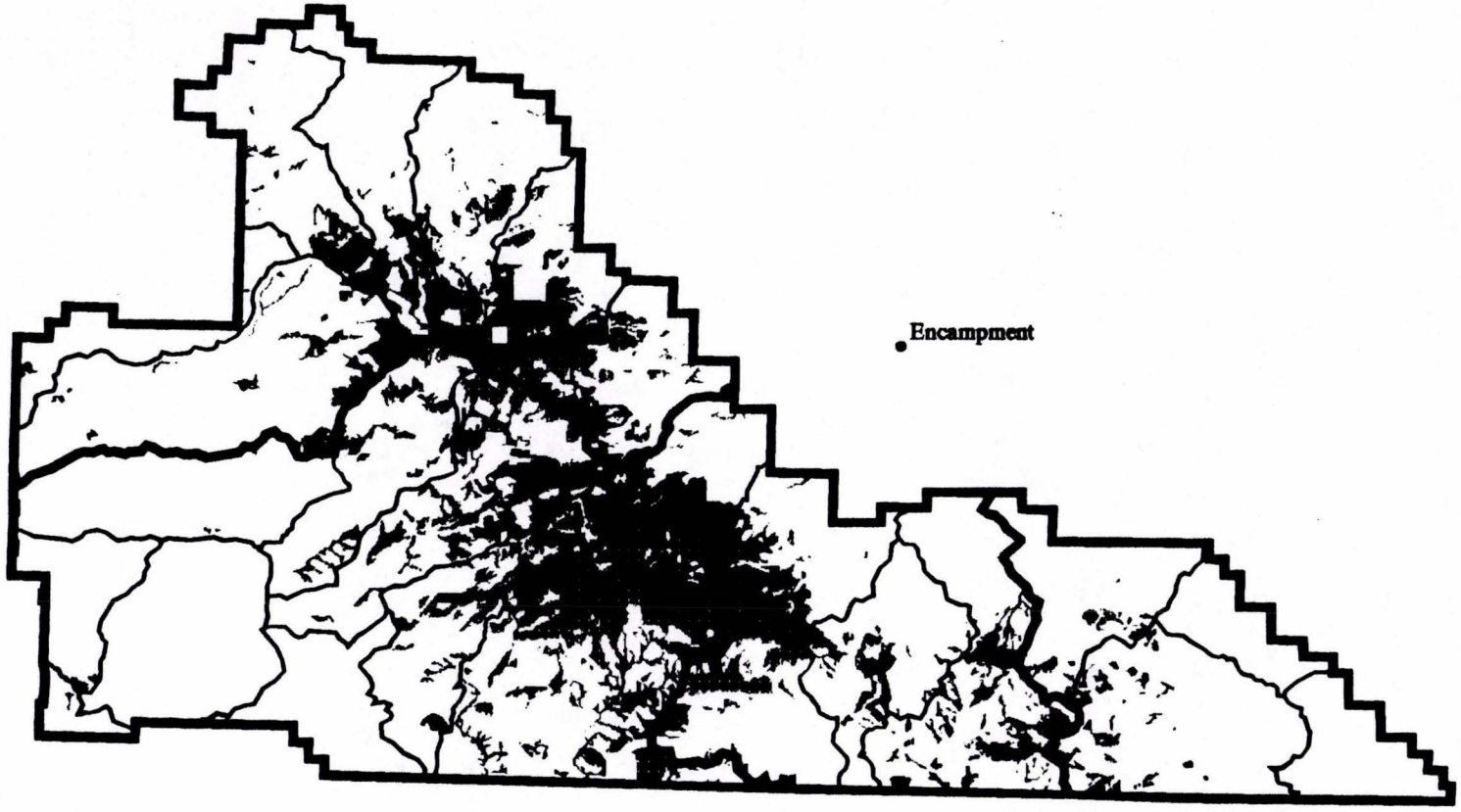
SIERRA MADRES

Spruce-fir Cover Type Location Map

FIGURE 6.8a

LEGEND

Spruce-fir



Biodiversity Unit Boundary

Biodiversity Area Boundary

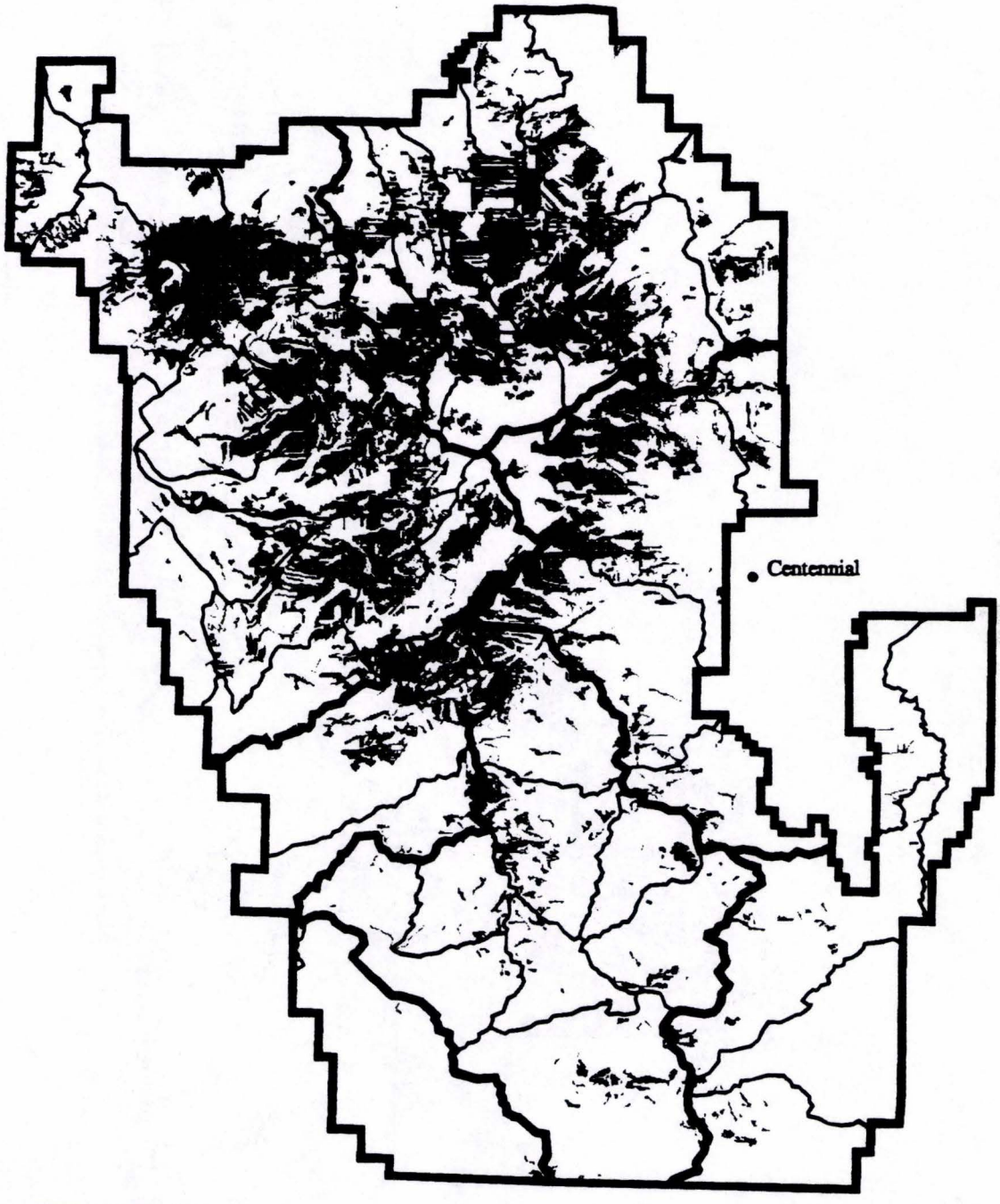
Scale 1 to 375,000

Created by CLT for JVA, 01/20/95, tsf_siesm.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Spruce-fir Cover Type Location Map

FIGURE 6.8b



Created by CLT for JVA, 01/20/95, tsf snowy.aml

LEGEND

- Spruce-fir cover type
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

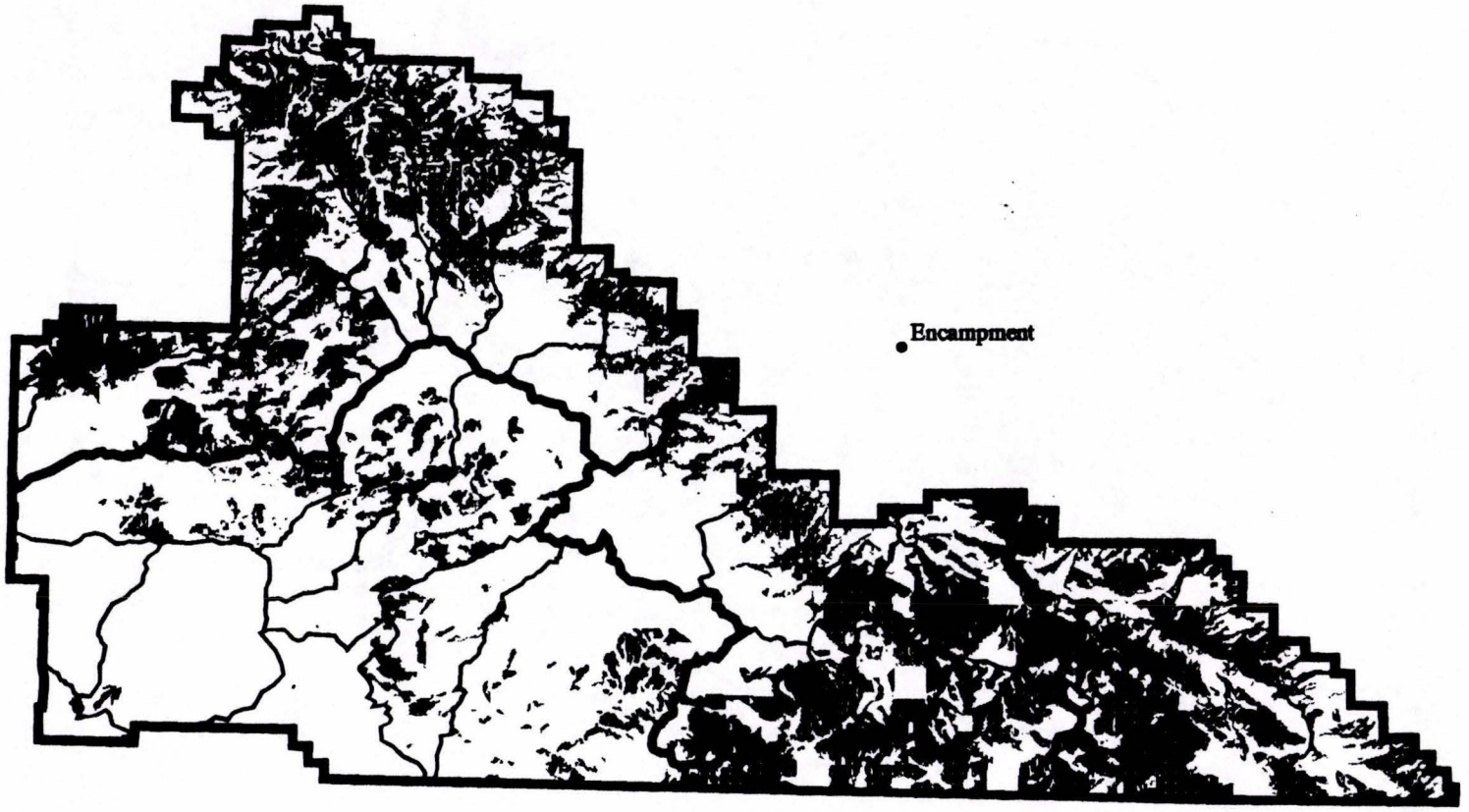
Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

SIERRA MADRES

Lodgepole Pine Cover Type Location Map

FIGURE 6.9a



LEGEND

- Lodgepole pine
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

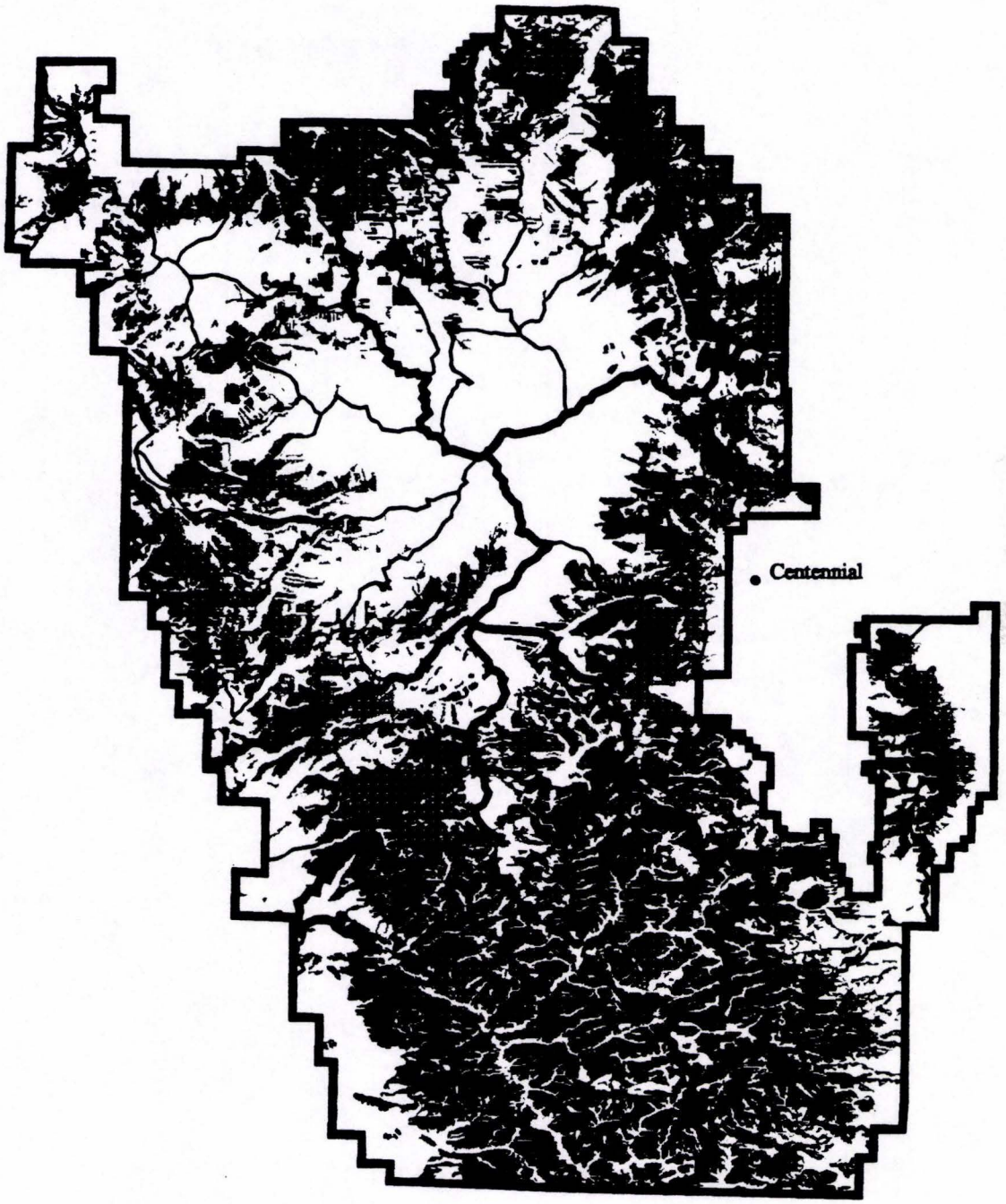
Scale 1 to 375,000

Created by CLT for JVA, 01/20/95, tlp_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Lodgepole Pine Cover Type Location Map

FIGURE 6.9b



Created by CLT for JVA, 01/20/95, dlg snowy.ansi

LEGEND

- Lodgepole pine
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

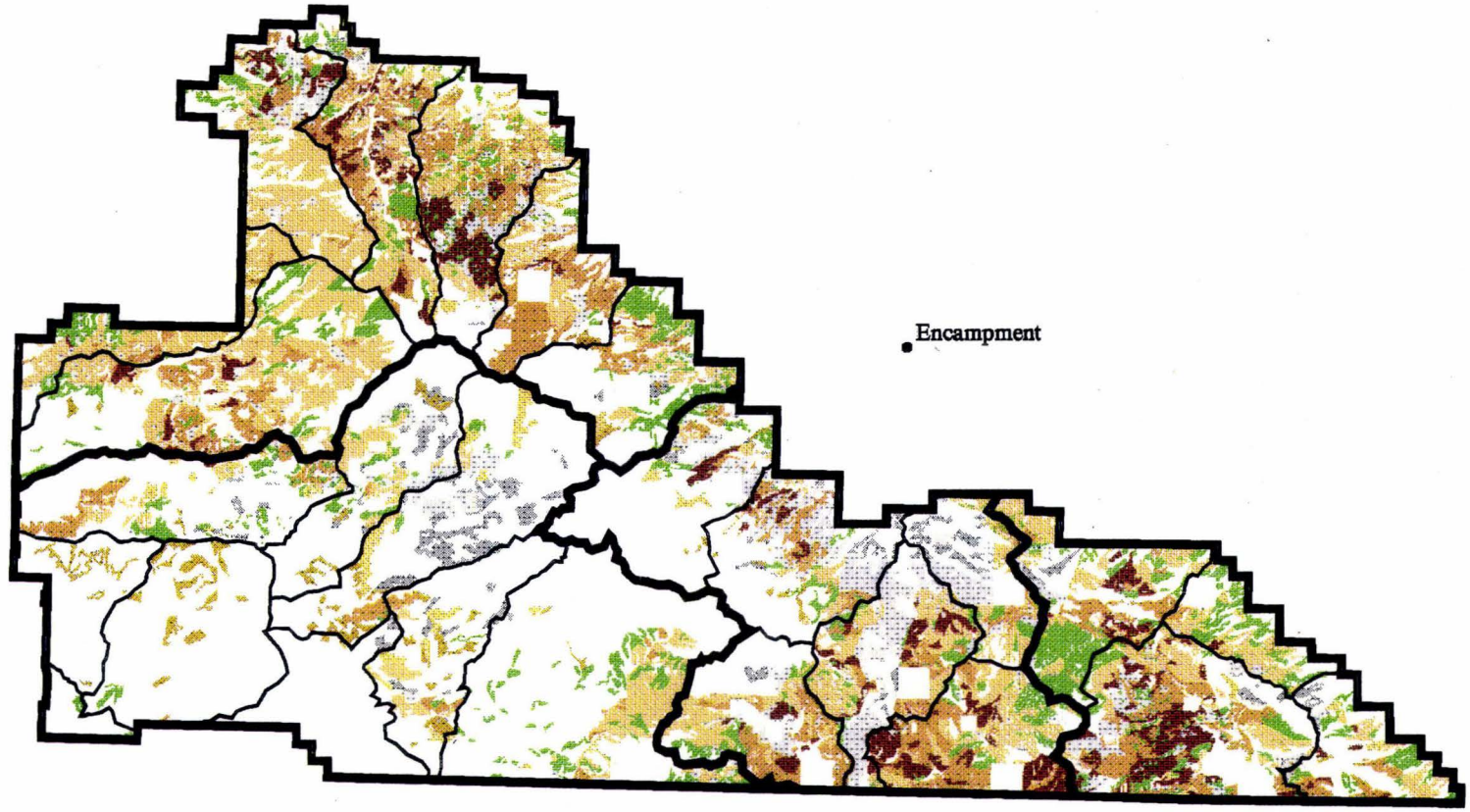
Scale 1 to 375,000

Distribution of Dwarf Mistletoe

FIGURE 6.10a

LEGEND

- Pine species, no data on dwarf mistletoe.
- Dwarf Mistletoe Absent
- Light Infection
- Medium Infection
- Heavy Infection
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

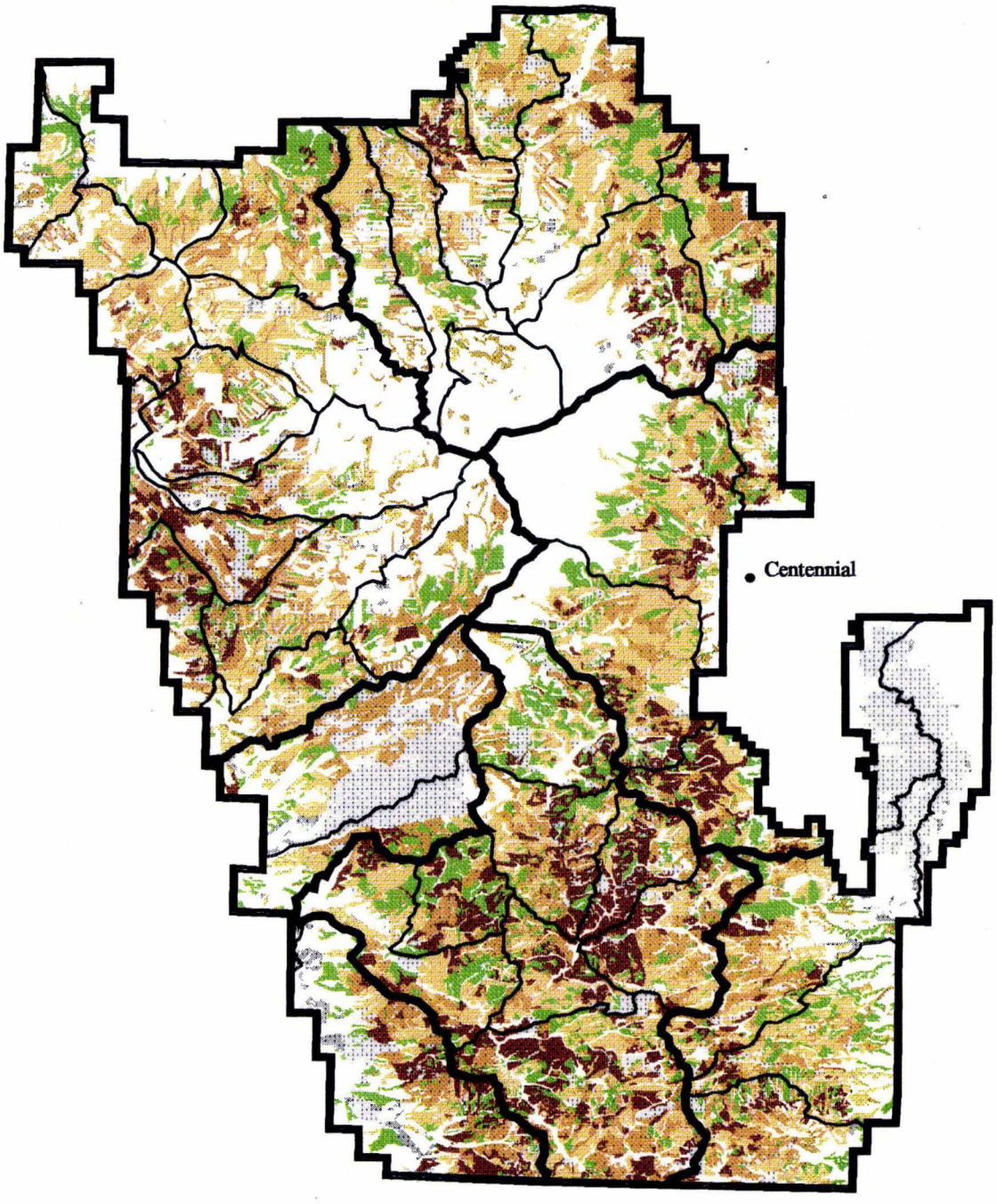
Created by CLT for JVA, 03.20.95, mist_sierra.aml

FIGURE 6.10a Distribution and infection levels of lodgepole pine dwarfmistletoe.

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Distribution of Dwarf Mistletoe

FIGURE 6.10b



Created by CLT for JVA, 03.17.95, mist snowy.aml

LEGEND

- Pine species, no data on dwarf mistletoe.
- Dwarf Mistletoe Absent
- Light Infection
- Medium Infection
- Heavy Infection
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

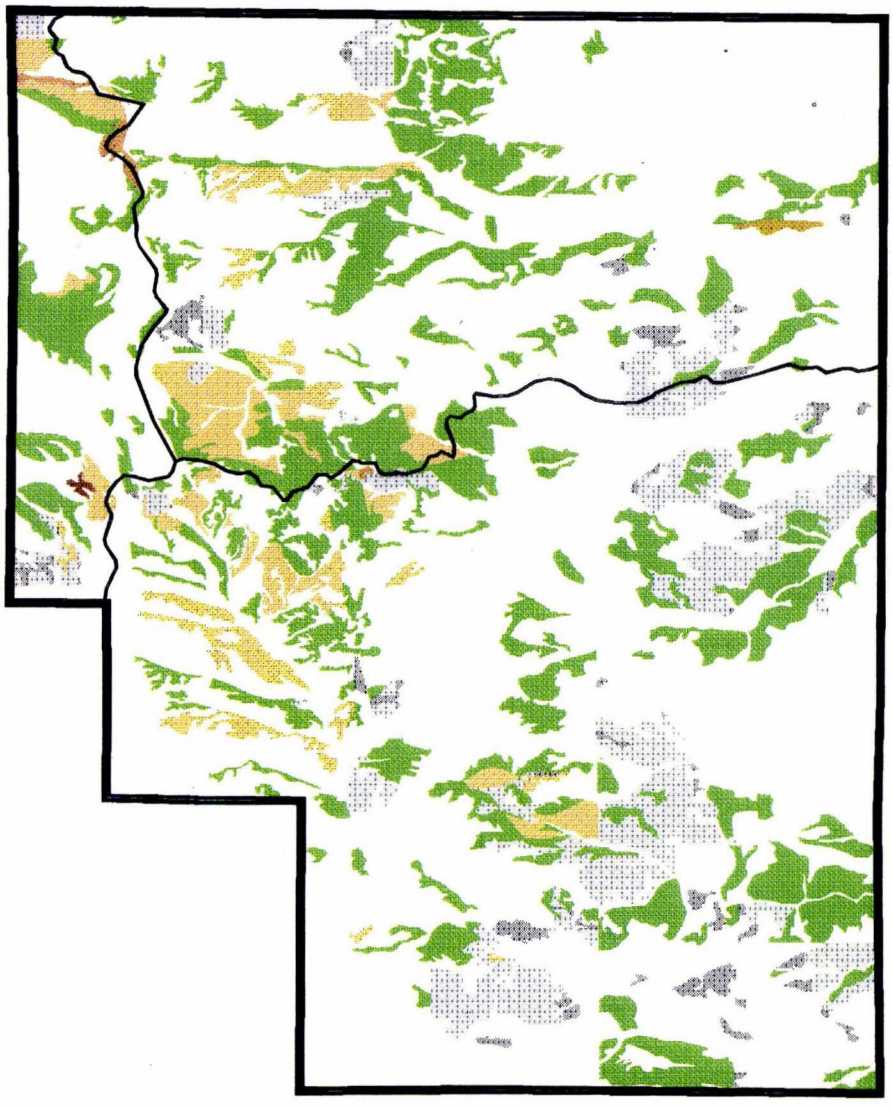
Scale 1 to 375,000

FIGURE 6.10b Distribution and infection levels of lodgepole pine dwarfmistletoe.

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Distribution of Dwarf Mistletoe

FIGURE 6.10c



Created by CLT for JVA, 03.20.95, mist sherman.aml

LEGEND

- Pine species, no data on dwarf mistletoe.
- Dwarf Mistletoe Absent
- Light Infection
- Medium Infection
- Heavy Infection
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

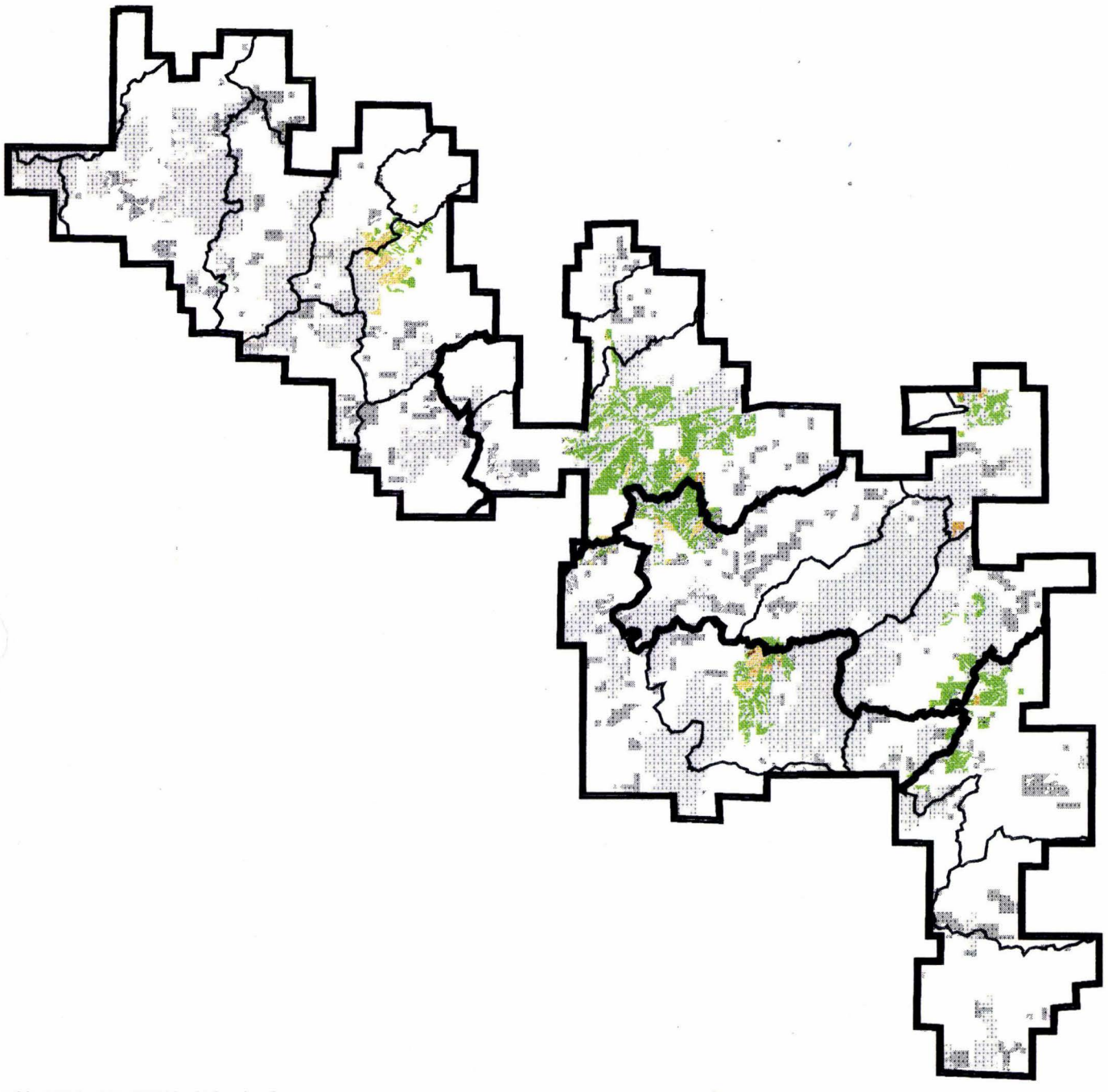
Scale 1 to 125,000

FIGURE 6.10c Distribution and infection levels of lodgepole pine dwarfmistletoe.

MEDICINE BOW NATIONAL FOREST — LARAMIE RANGE

Distribution of Dwarf Mistletoe

FIGURE 6.10d



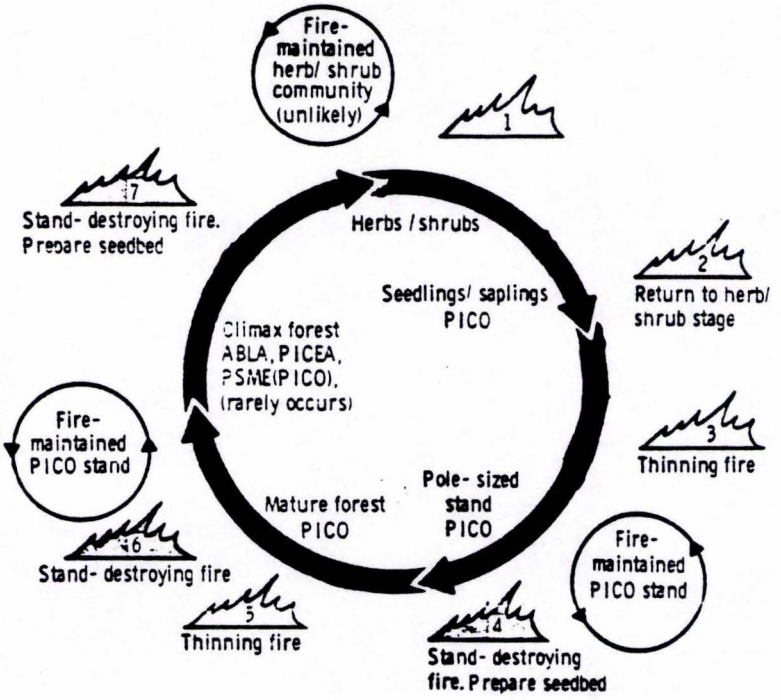
Created by CLT for JVA, 03.20.95, mist_laramie.aml

LEGEND

- Pine species, no data on dwarf mistletoe.
- Dwarf Mistletoe Absent
- Light Infection
- Medium Infection
- Heavy Infection
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 425,000

FIGURE 6.10d Distribution and infection levels of lodgepole pine dwarfmistletoe.



Legend :

Generalized forest succession

Cool fire

Severe fire

FIGURE 6.11 Generalized forest succession diagram for lodgepole pine in cool habitat types (Fischer and Clayton, 1983).

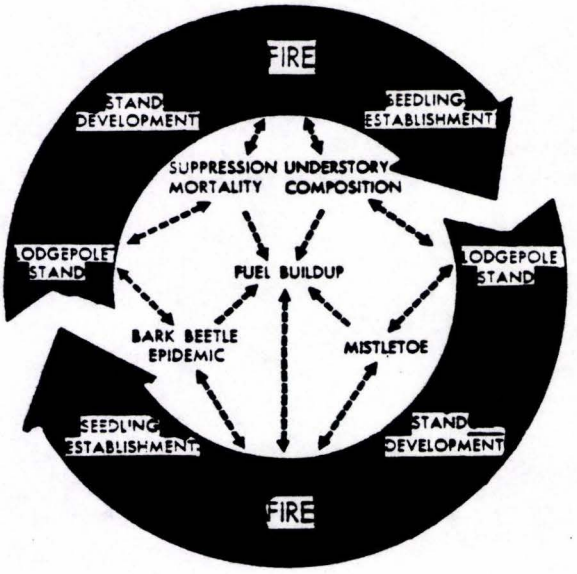


FIGURE 6.12 Generalized fire cycle diagram for lodgepole pine (Lotan et al. 1984).

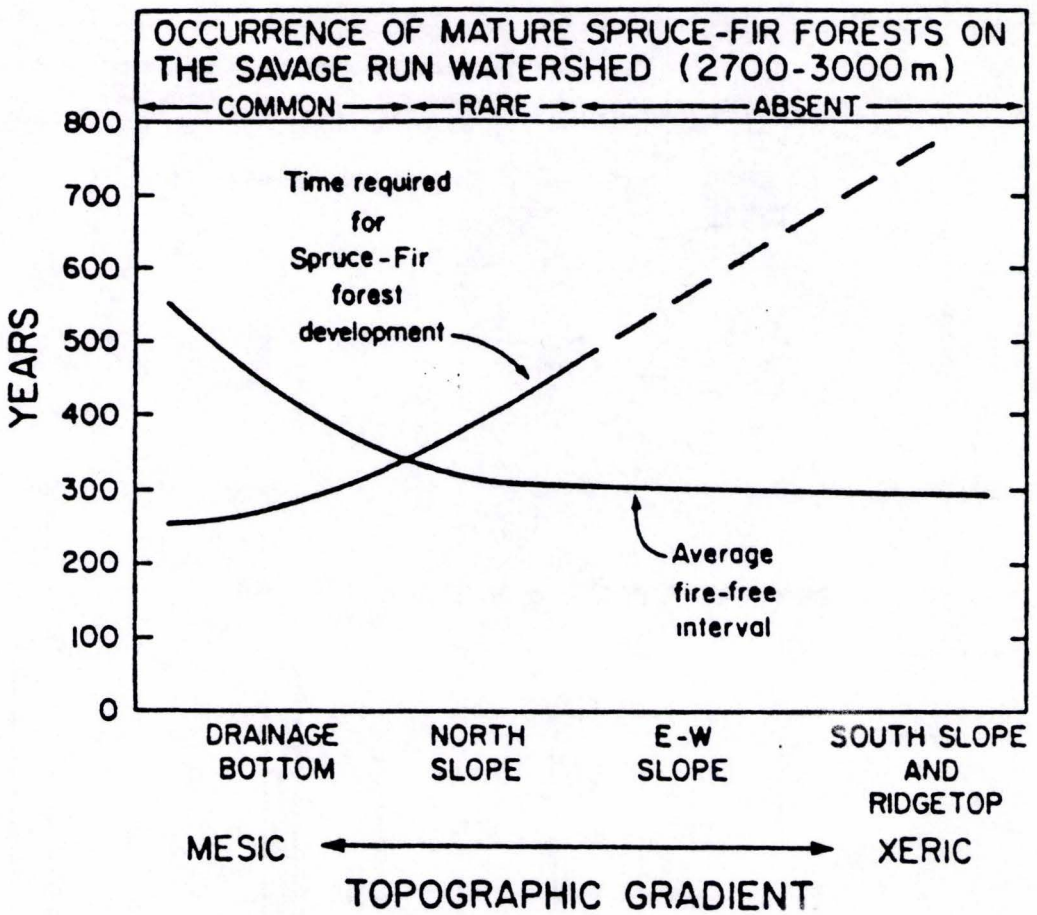
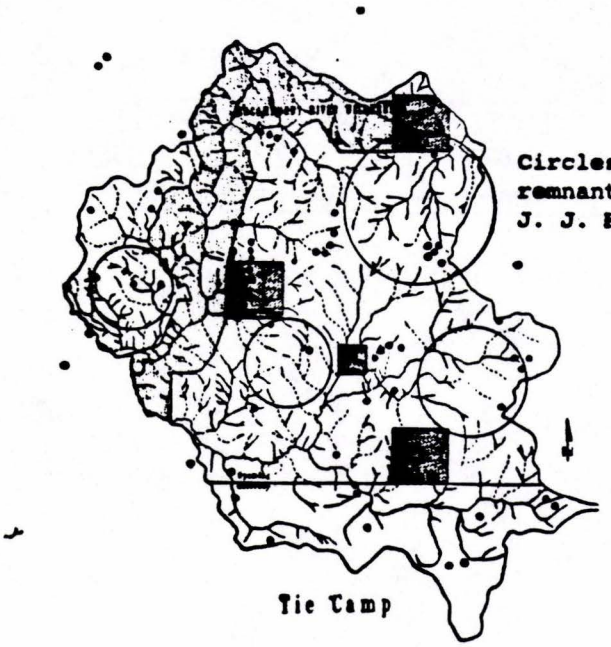


FIGURE 6.13 Concept diagram for spruce-fir forest development for topography, time, and estimated average fire-free interval for Savage Run Wilderness Area (8800-9800 feet) (Romme and Knight 1981). Fire-free intervals may be longer for lower topographic positions and cooler north-facing slopes than warm slopes aspects and higher topographic positions.



Circles represent areas of possible remnant forests. Courtesy of J. J. Honaker.

= State Land

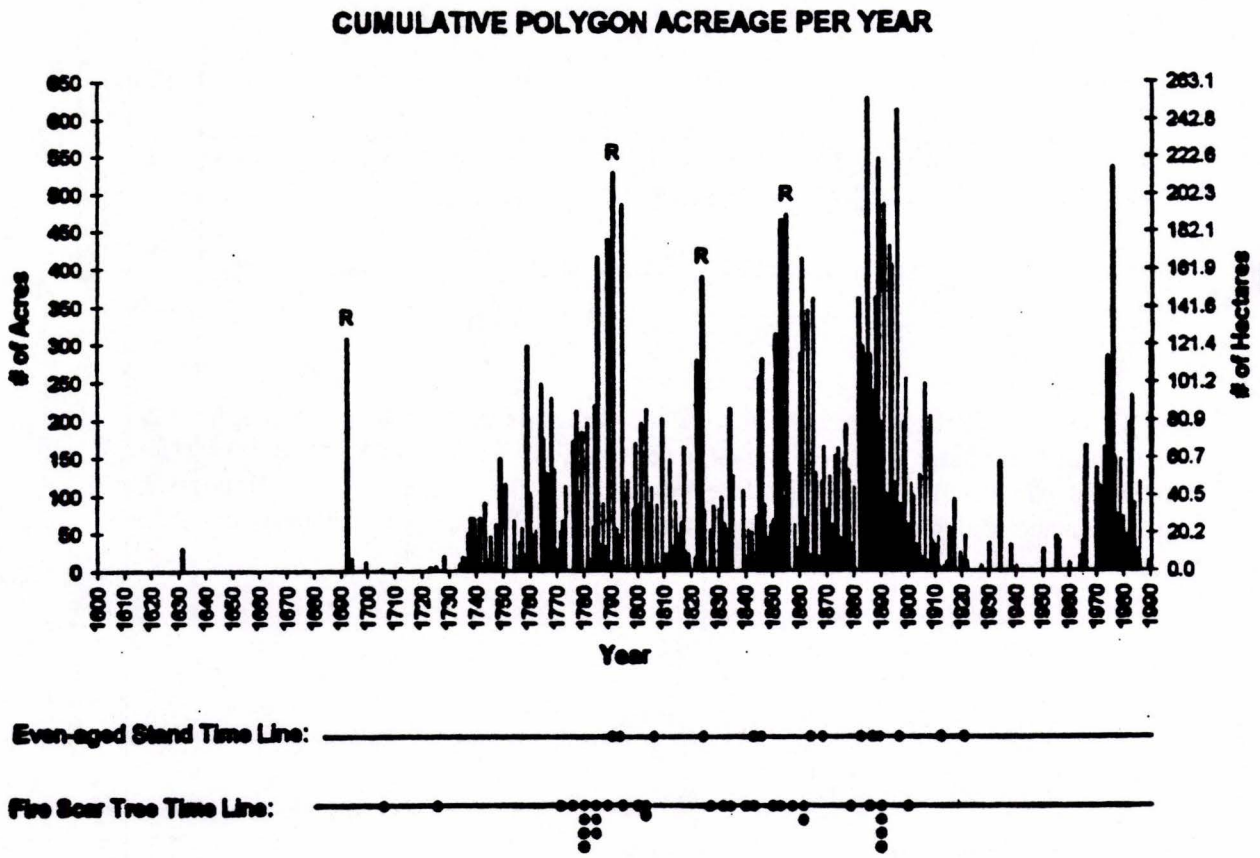


FIGURE 6.14 Vertical lines represent cumulative acreage representing stand ages derived from stand origin dates (Stage II Inventory-RIS database) in the Tie Camp area. The increase in acres with origin dates 1880-1910 are believed to be from tie-hacking and associated fires. The drop in acreage of stands originating from 1910 to the late 1960s is attributed to effective fire suppression. Stands originating since the 1960s are mainly from timber harvest. "R" indicates clusters of possible remnant stands from previous stand-replacing fires. Courtesy of J.J. Honaker (1994) - Master's Thesis research results.

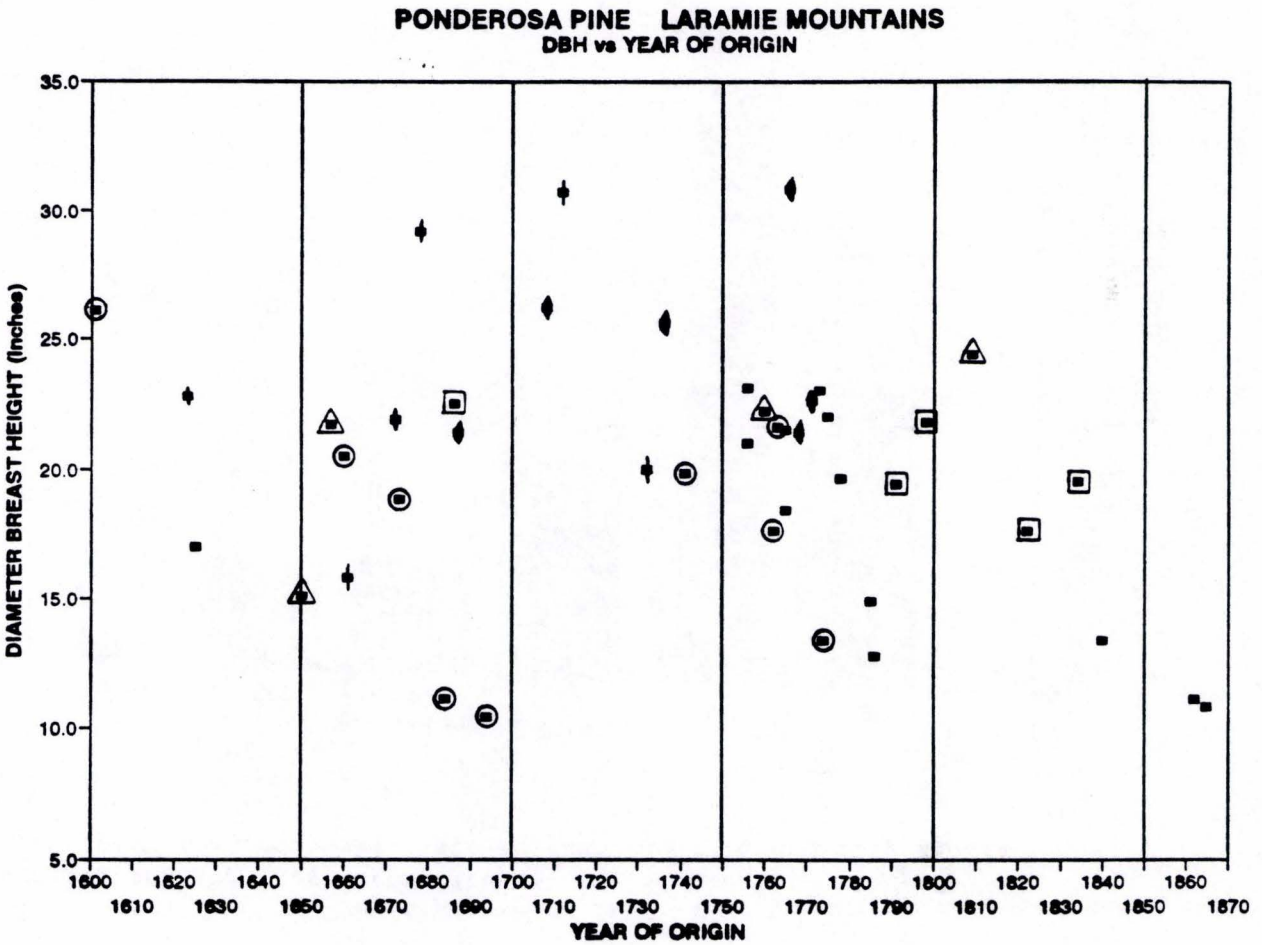


FIGURE 6.15 Relationship of tree age and tree dbh for ponderosa pines in the Ashenfelder Basin, Rock Mountain area near Laramie Peak. Possible remnant cohort groups may have established in the mid-1700s. Catastrophic fires did not occur in this area since at least 1600. (compiled by von Ahlefeldt from Jones (1989) and Sobzcak (1987).

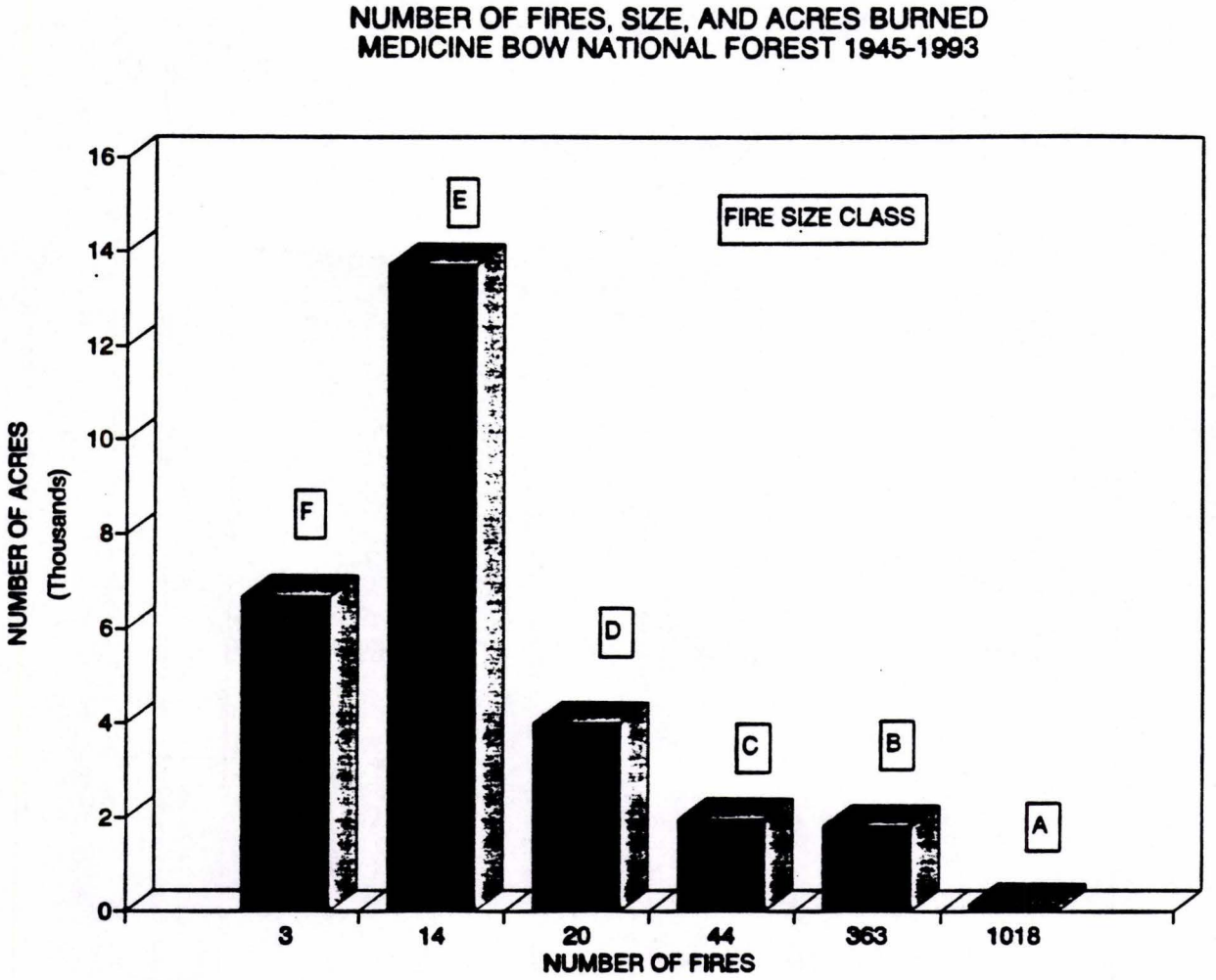


FIGURE 6.16 Number of fires by size class compared to acres burned by size class, since 1945, for the Medicine Bow National Forest.

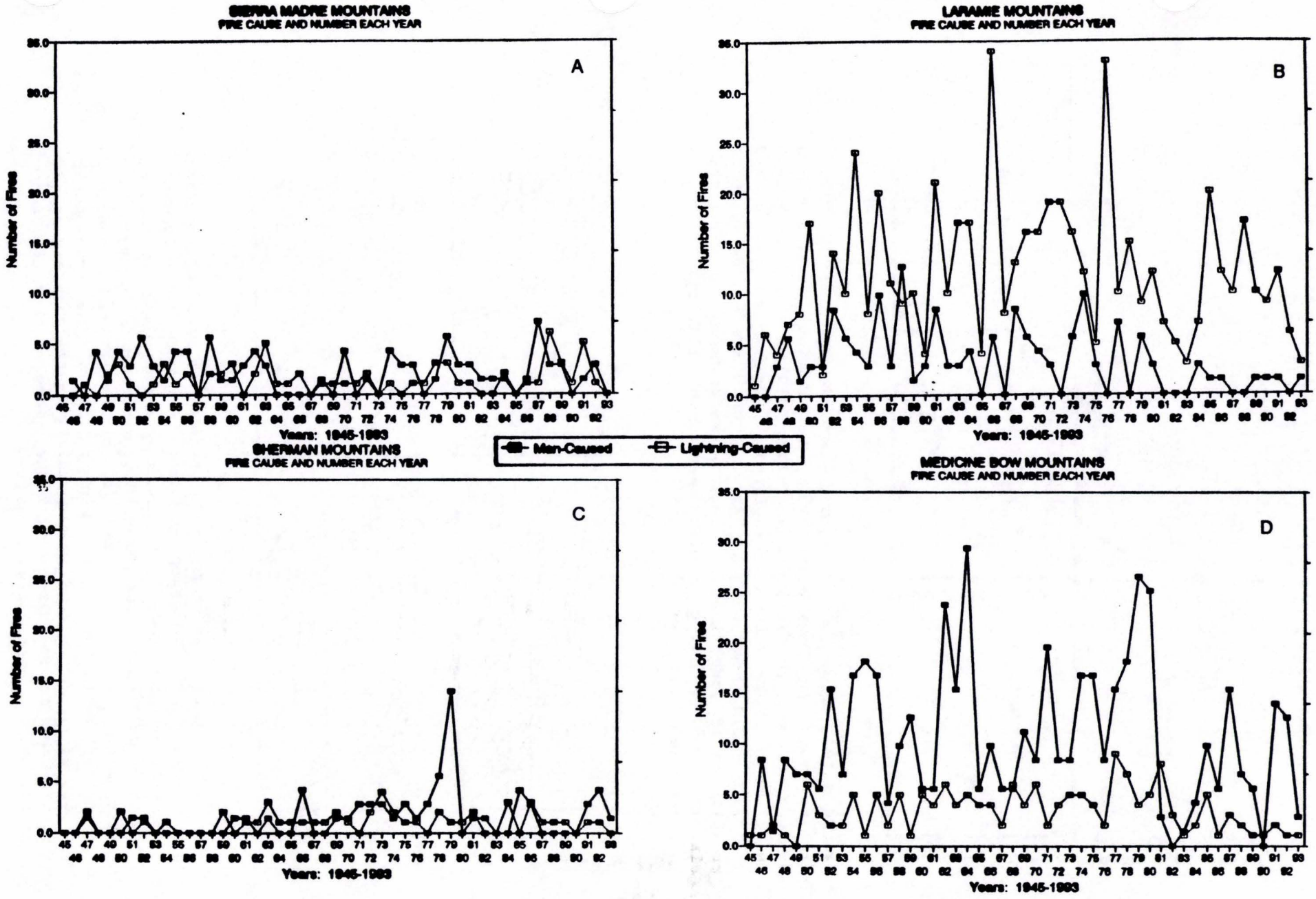


FIGURE 6.17 Fire occurrence and cause, by year, for each mountain range in the Medicine Bow National Forest. (MBNF Fire records, Laramie, WY).

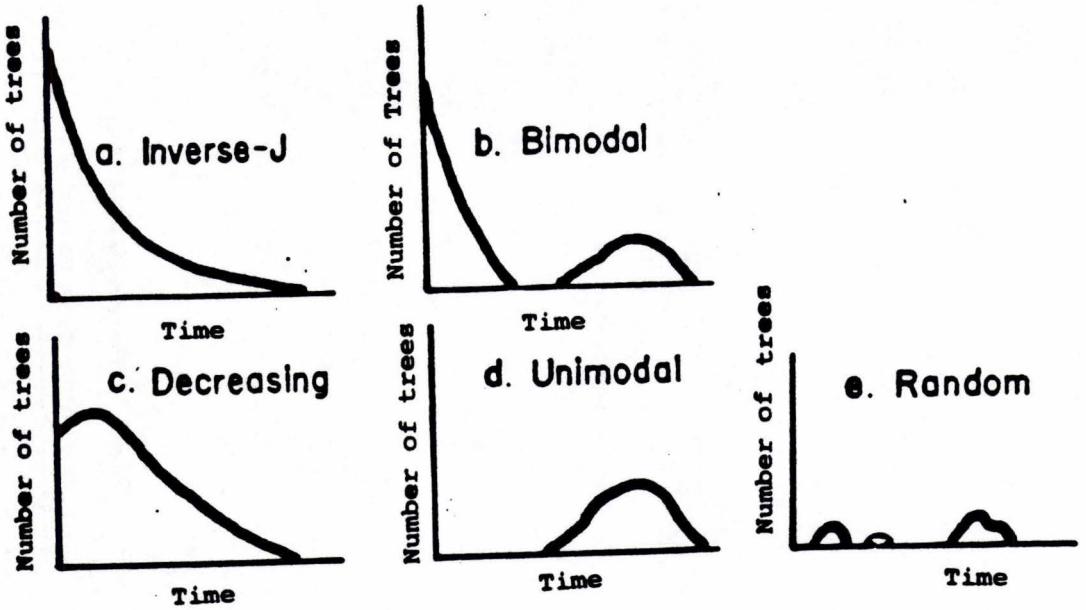


FIGURE 6.18 Diversity of types of age structure in spruce-fir forests resulting from differential recruitment, mortality and disturbance regimes (Whipple and Dix, 1979). a. continuous recruitment and mortality (climax forest) b. pulsed recruitment and mortality - old trees and young trees predominate c. decrease in recruitment of young trees d.lack of recruitment in young ages classes e. no regular pattern of recruitment or mortality.

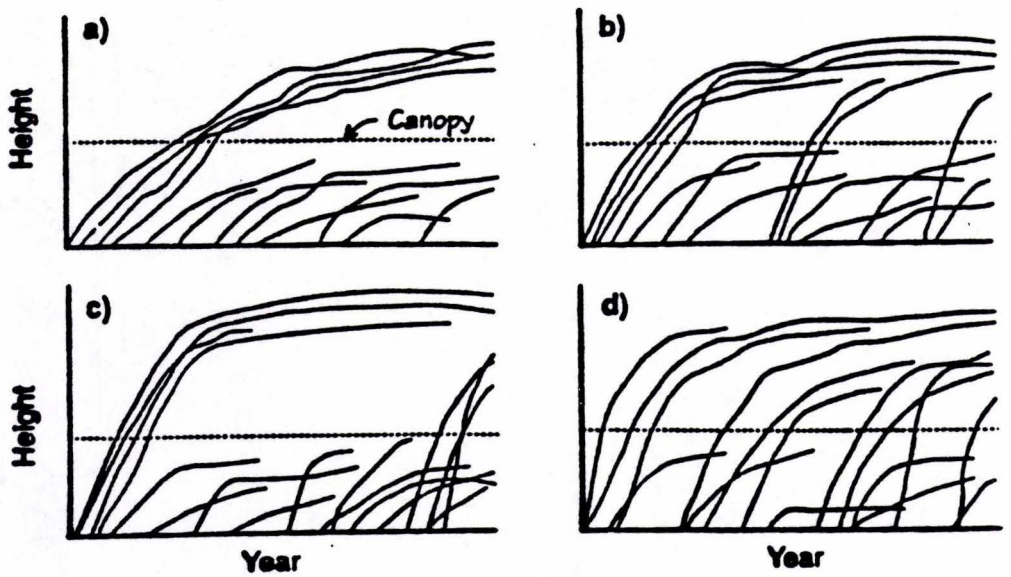


FIGURE 6.19 Continuum of possible patterns of tree reproduction and recruitment into the canopy for lodgepole pine-spruce forests. a. there is no recruitment of subcanopy trees after an initial canopy grows following a stand-replacing distrubance b. there is a discrete period of canopy entry for older-aged trees possibly following infrequent formation of canopy gaps c. older trees enter the canopy after age-related tree mortality causes canopy gaps d. understory trees are recruited continuously enabled by random canopy gap formation. (Johnson et al., 1994).

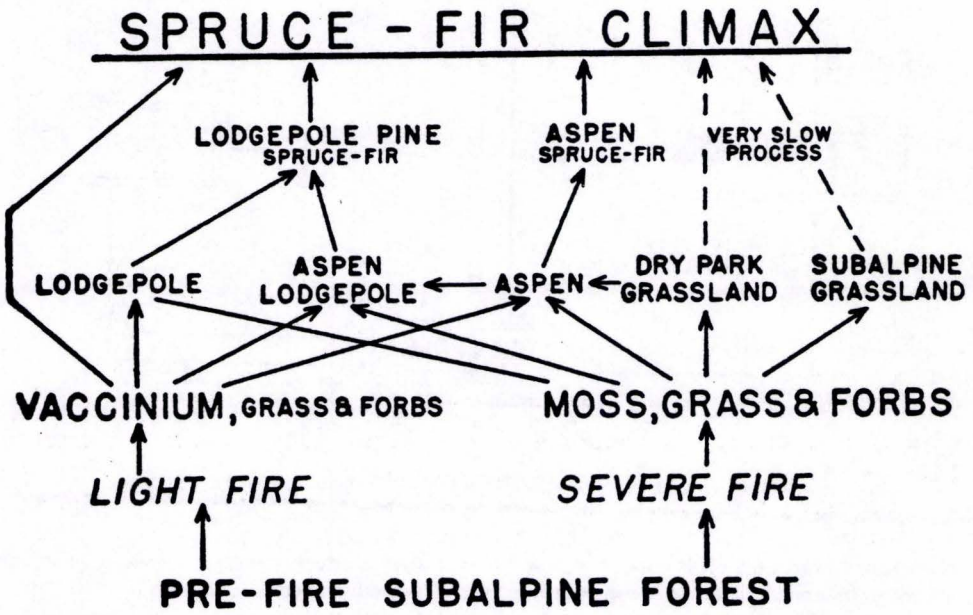
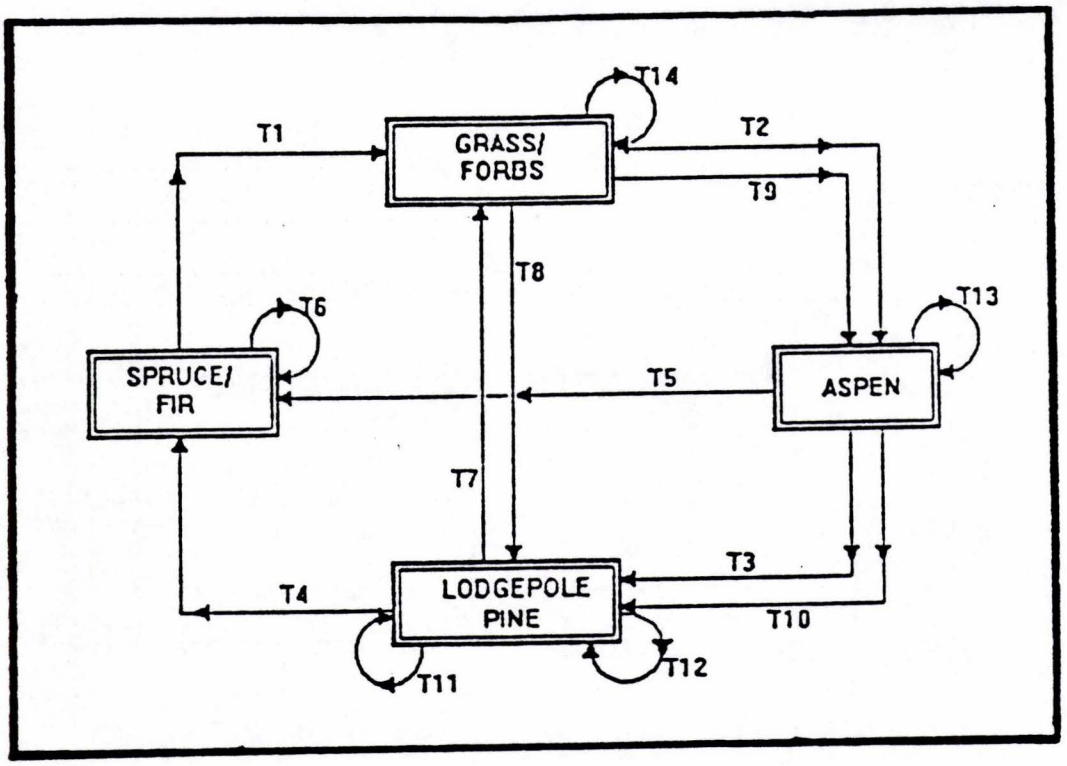


FIGURE 6.20 Diagram of major successional trends following light or severe forest fires in subalpine forests of the Rocky Mountains (Stahelin, 1943). The vertical axis is time, the horizontal represents a limited elevation gradient.

State-and-Transition Model



T1 — Catastrophic fire, possibly in concert with an insect or disease attack, combine to convert a spruce/fir forest type back to the grass shrub stage where aspen or lodgepole pine can become established.

T2 — Aspen becomes established and eventually becomes the dominant species.

T3 — As aspen grows old, the stand degenerates and lodgepole pine becomes established in openings (see T5).

T4 — As lodgepole stands grow old it is gradually replaced by a shade tolerant spruce/fir component.

T5 — As aspen grows old the stand degenerates and is replaced by a spruce/fir component. The transition to lodgepole pine (T10) is the most common on the Sierra Madre Range. The transition to spruce/fir occurs under conditions favorable to that species such as north facing slopes, or the available seed source.

T6 — The spruce/fir stage is maintained through management activities such as group selection cuts, uneven-aged management or a shelterwood system. Without natural or human-made disturbance, the spruce/fir stage will maintain itself through regeneration. Spruce/fir is maintained in the absence of fire.

T7 — The result of fire or clearcutting, the mature stand of lodgepole is taken back to the grass forb stage.

T8 — The transition from the grass/forb state back to lodgepole pine and occurs when a sufficient source of viable seed is present.

T9 — The transition from the grass/forb state to aspen and occurs when viable seed source for lodgepole pine is not present.

T10 — The transition from aspen to lodgepole pine.

T11 — The transition when lodgepole pine is clearcut and immediately planted back to lodgepole pine.

T12 — The transition under management where lodgepole pine is managed under a shelterwood or clearcut harvest system to retain lodgepole pine.

T13 — The transition under management where mature aspen is clearcut or burned to promote regeneration to retain aspen.

T14 — The transition under range management through which grazing or burning maintains the grass/forb state.

FIGURE 6.21 State-and transition model of succession among grass-forb, lodgepole pine, spruce-fir and aspen ecosystems for the Sierra Madre Mountains (USDA Forest Service, 1993). The boxes represent stable states which last for varying but fairly long periods of time, while the arrows represent transitional states which are shorter, and specific driving factors associated with them.

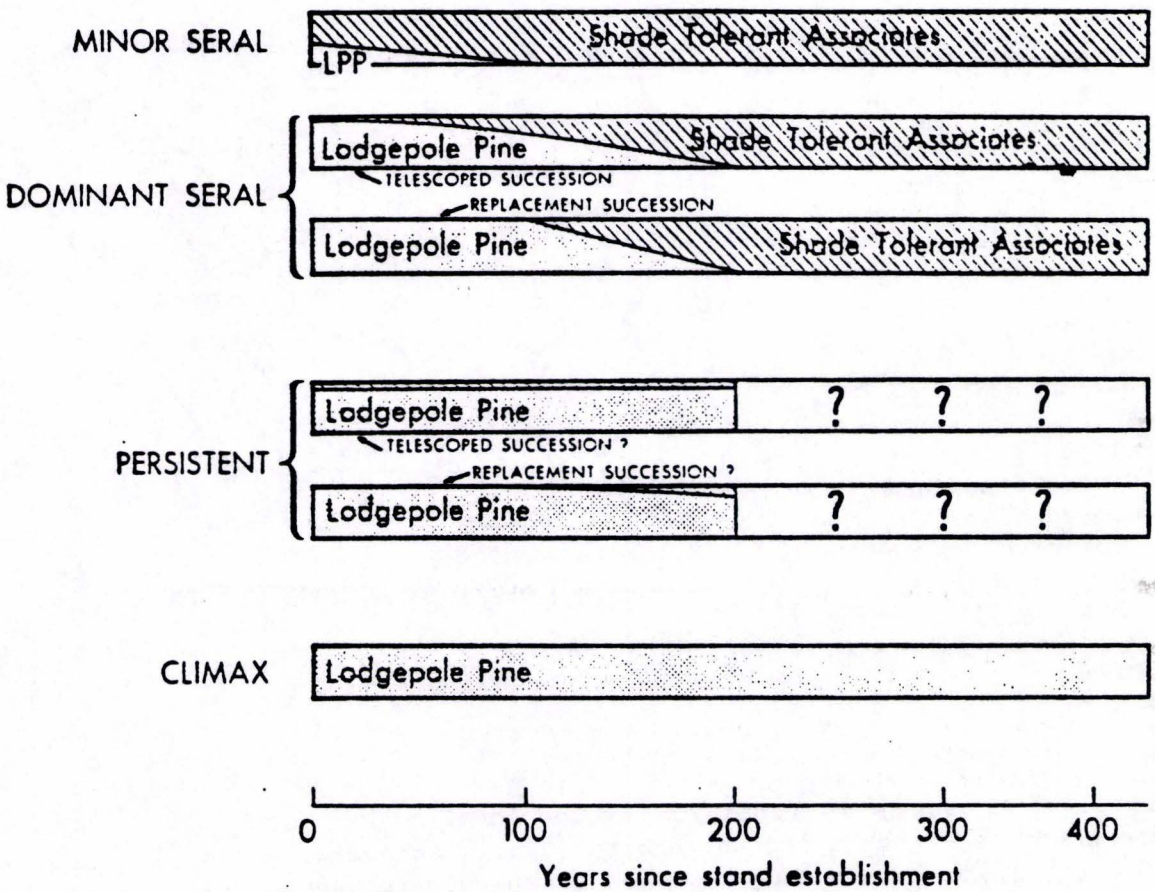


FIGURE 6.22 Successional models for lodgepole pine forests. "Telescoped succession" refers to co-establishment of several tree species immediately following disturbance (Pfister and Daubenmire, 1975). It might be noted that 400 years is not necessarily an life span for these forests as the closed boxes might imply.

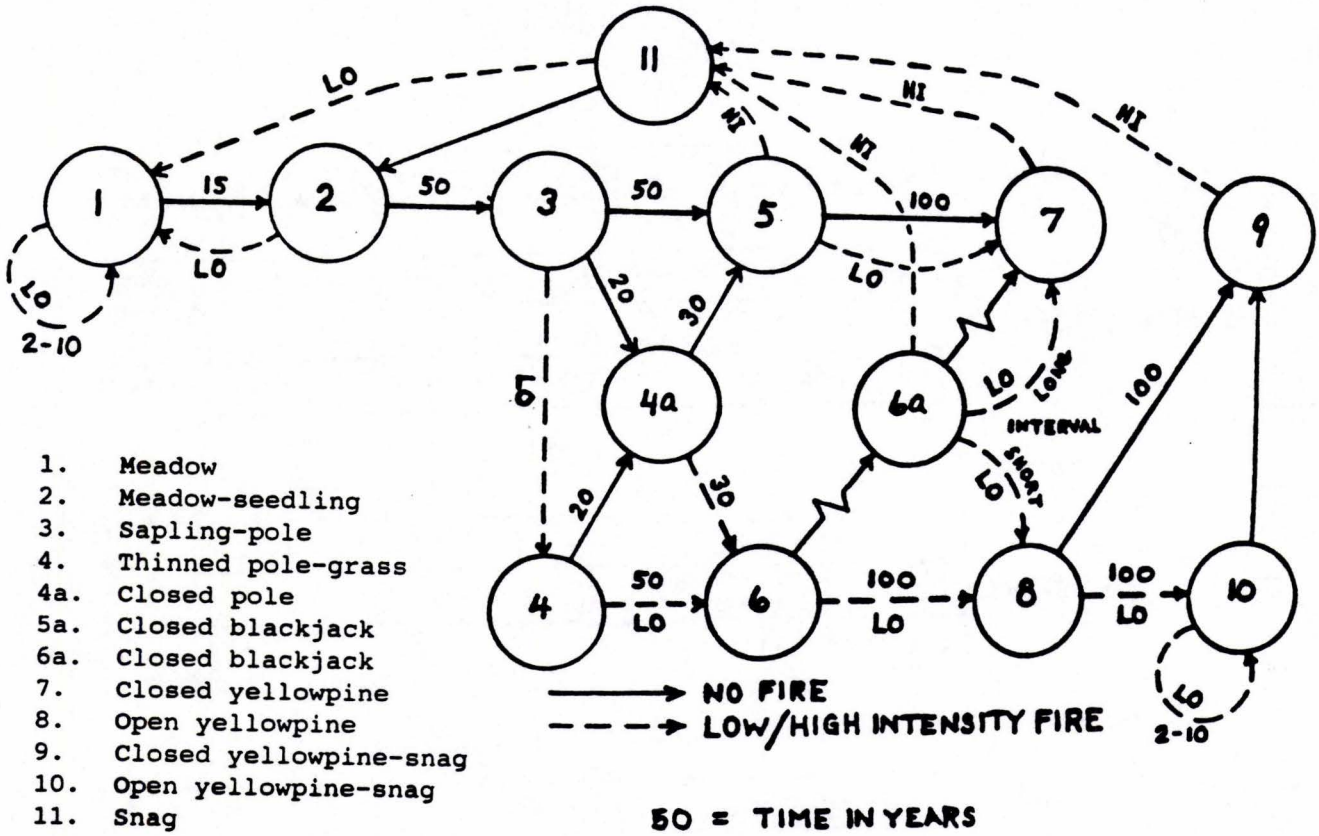


FIGURE 6.23 Sate and transition successional model for Arizona ponderosa-pine bunchgrass habitat type. Stages 8, 9 and 10 are threshold (open an parklike), degenerate (presence of saplings, poles and snags) and climax (open, large trees and snags) old growth. Threshold old growth is attained in about 100 years. Additional old growth characteristics develop after 200 years and are best expressed after 300 years (Moir and Dieterich, 1988)

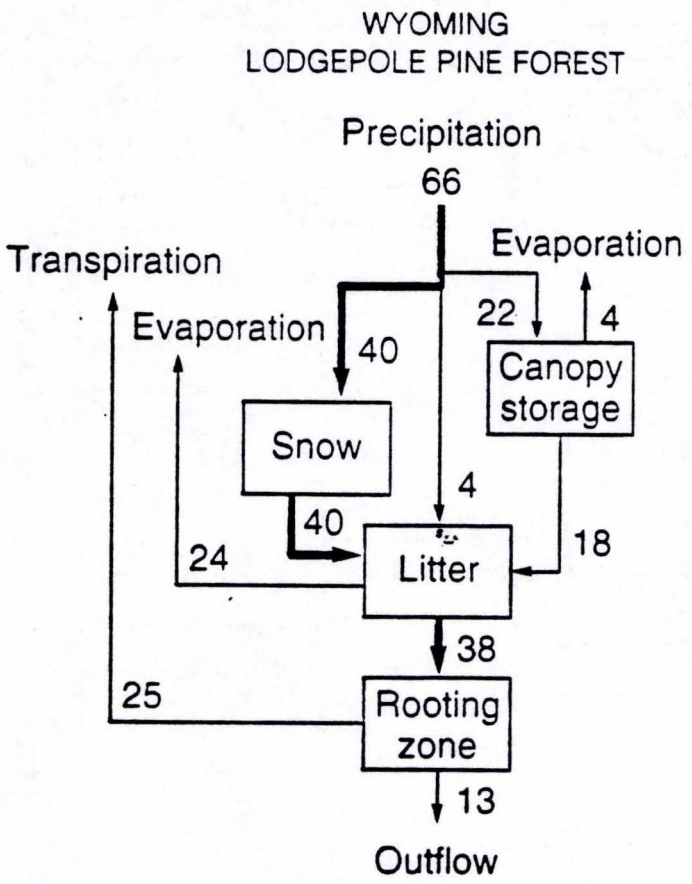


FIGURE 6.24 Forest hydrology water budget for a lodgepole pine forest near Foxpark, Wyoming (Knight, 1994). Numbers are centimeters of precipitation. Sixty-six centimeters is about 24 inches. About 1/3 is intercepted by the canopy and 2/3 reaches the ground as snow. Available precipitation for streamflow is 13/66 centimeters or about 20%,

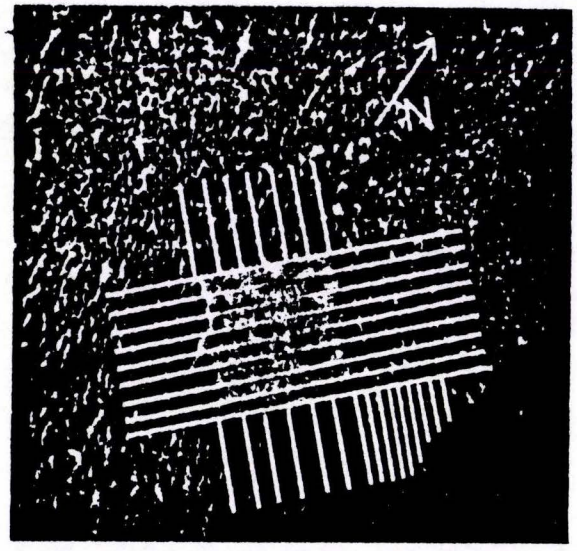


FIGURE 6.25 Aerial view of 5H-wide (5 tree heights) clearcut experiment to determine snow catchment in openings, and effects on snow deposition on the lee side of openings.
These snow transects were part of a series of experiments set up a few miles southeast of Foxpark between 1970 and 1978 by Gary (1980). Note the position of the north arrow.

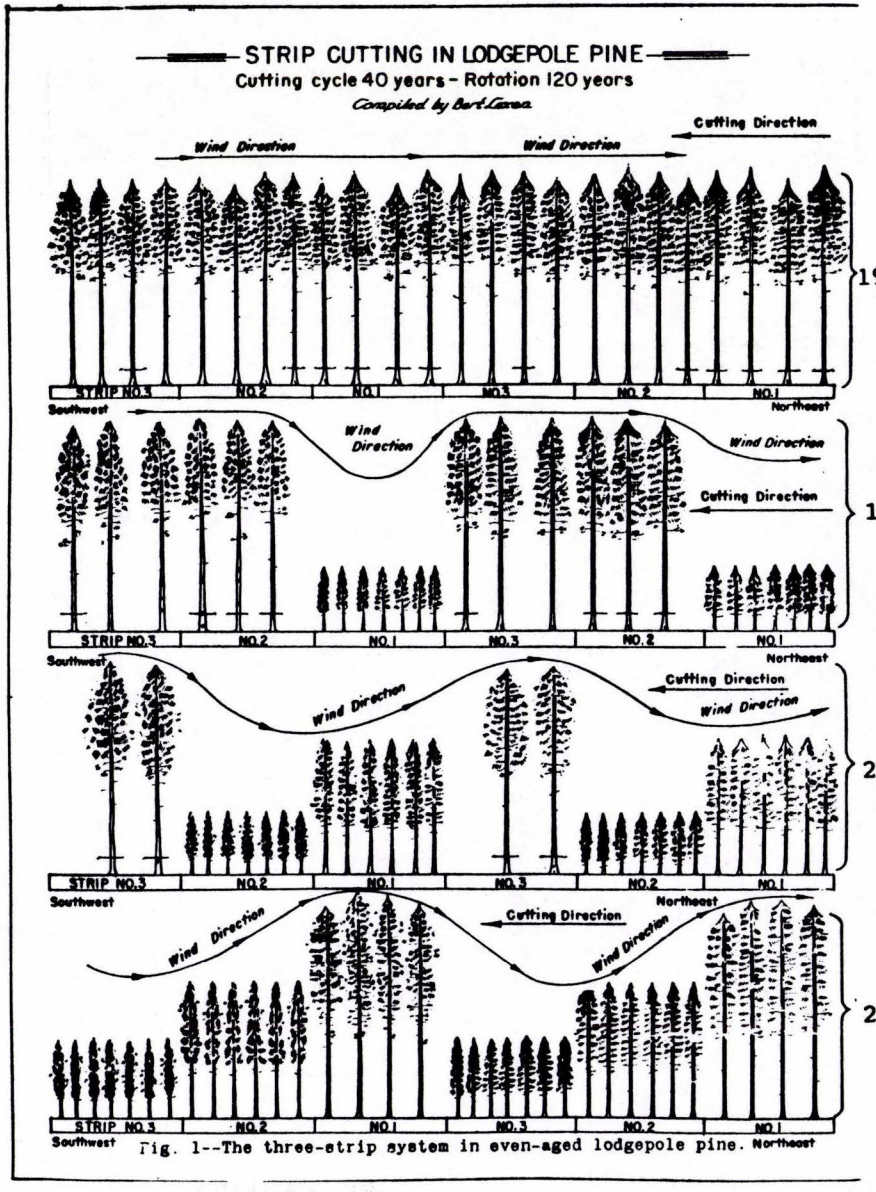


FIGURE 6.26a Three strip system with a 120 year rotation and a 40 year cutting cycle applied to even-aged stands. (Lexen, 1949)

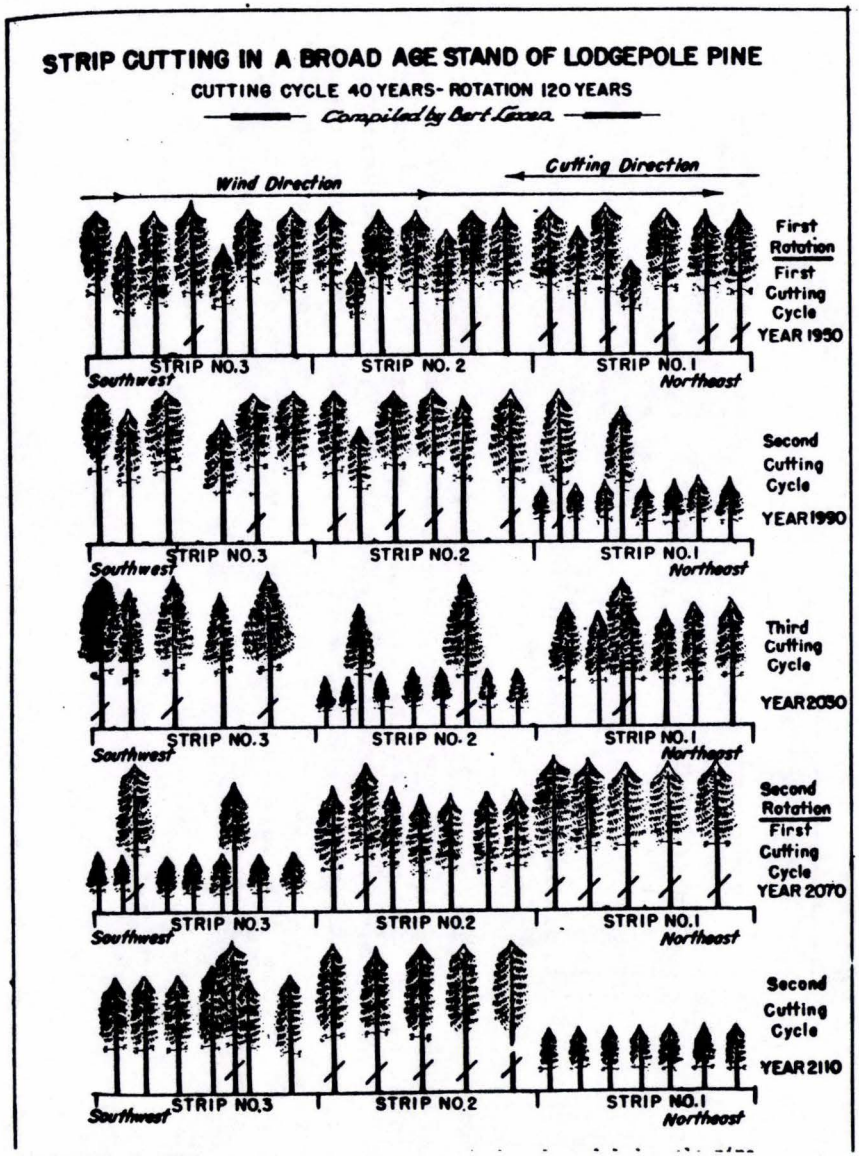


FIGURE 6.26b Three strip system for broad-aged stands. Conversion of the broad-aged stands to even-age stands does not occur until the end of the second cutting cycle in the second rotation. (Lexen, 1949)

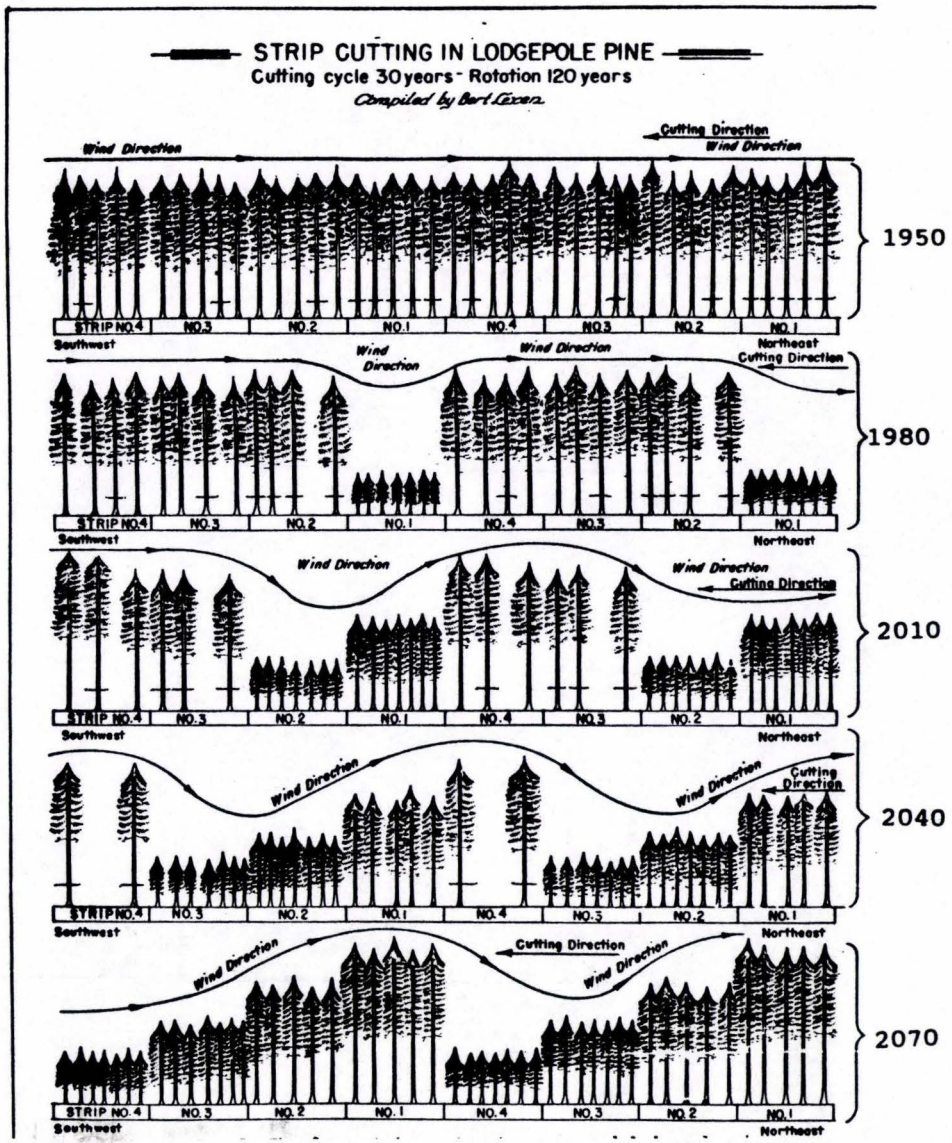


FIGURE 6.26c Four strip system, 120 year rotation, 30 year cutting cycle. More cuts, but less volume per cut. (Lexen, 949)

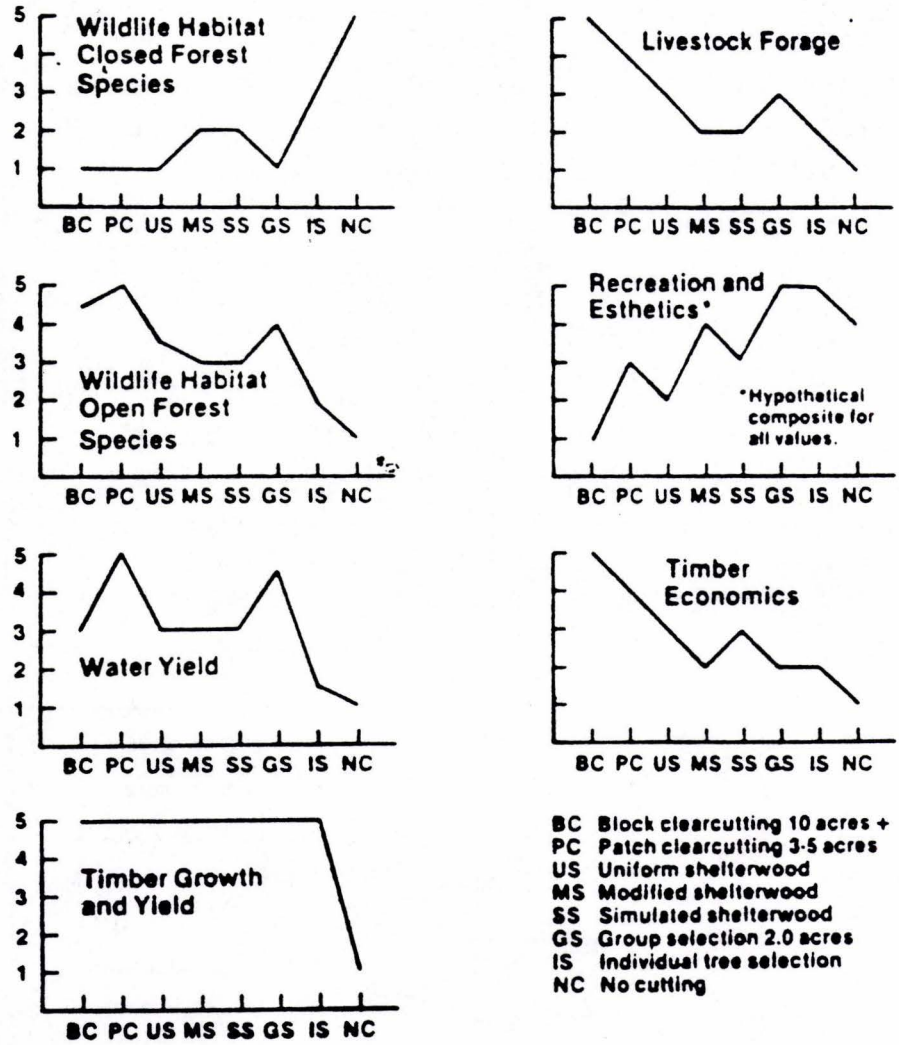


FIGURE 6.27 Relative rankings of the effect of silvicultural systems on the resources of spruce-fir forests (Scale: 1 = least favorable; 5 = most favorable) (Alexander, 1977). Additional graphs could be developed for effects of silvicultural systems on other aspects of biological diversity such as lichens, decay processes, populations of invertebrates, and seedling establishment and survival.

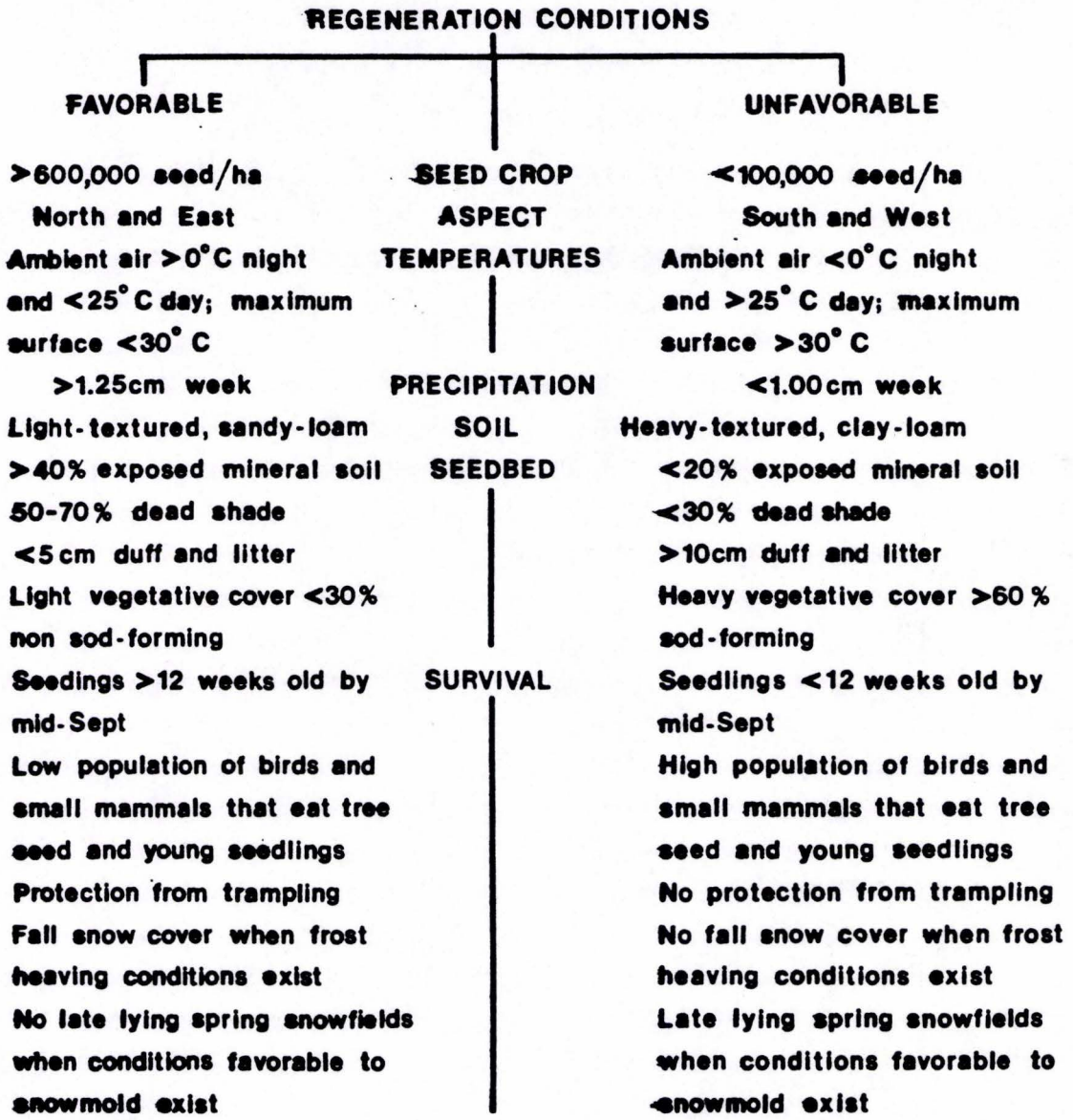


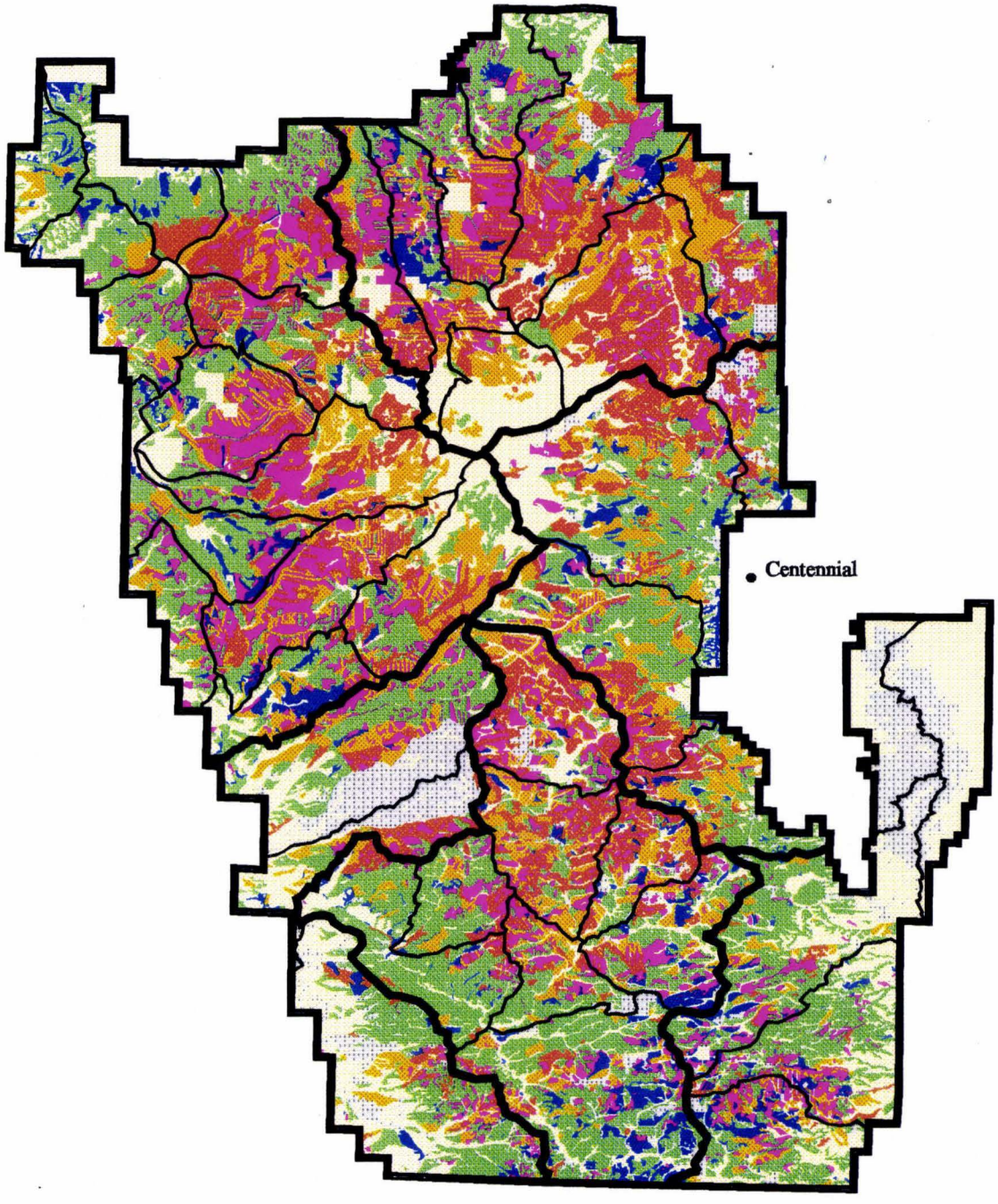
FIGURE 6.28 Conditions favorable and unfavorable to the natural regeneration of Engelmann spruce (Alexander, 1984).

MEDICINE BOW NATIONAL FOREST

Stand Age Map

SNOWY RANGE

FIGURE 6.29a



Created by CLT for JVA, 01/19/95, age snowy.aml

LEGEND

- 195 years old and older (year of origin <= 1799)
- 145 through 194 years old (year of origin 1800-1849)
- 84 through 144 years old (year of origin 1850-1910)
- 45 through 83 years old (year of origin 1911-1949)
- 44 years old and younger (year of origin >= 1950)
- No age data forested
- No age data other (openings, State, Private, water)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

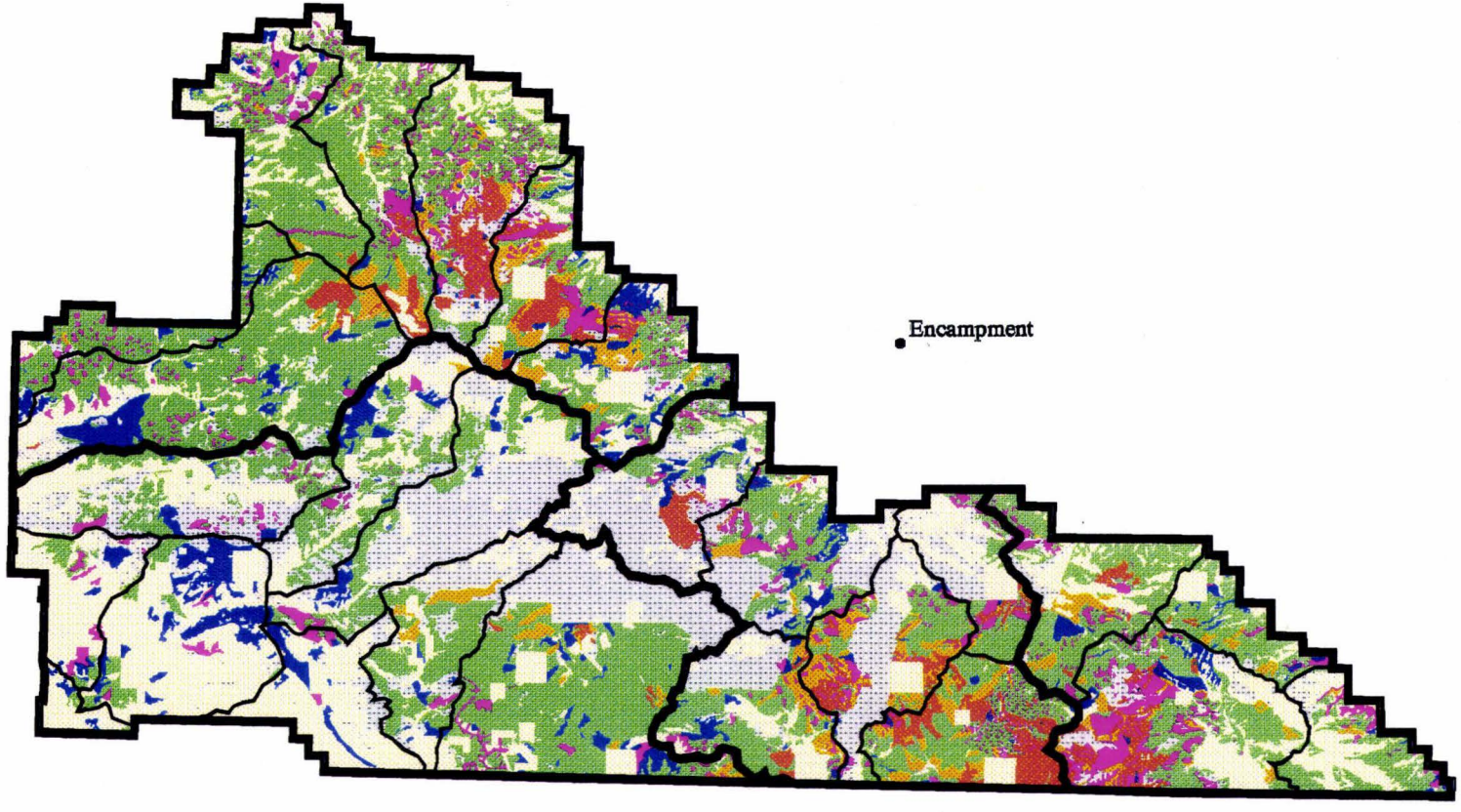
Scale 1 to 375,000

MEDICINE BOW NATIONAL REST

SIERRA MAD

Stand Age Map

FIGURE 6.29b

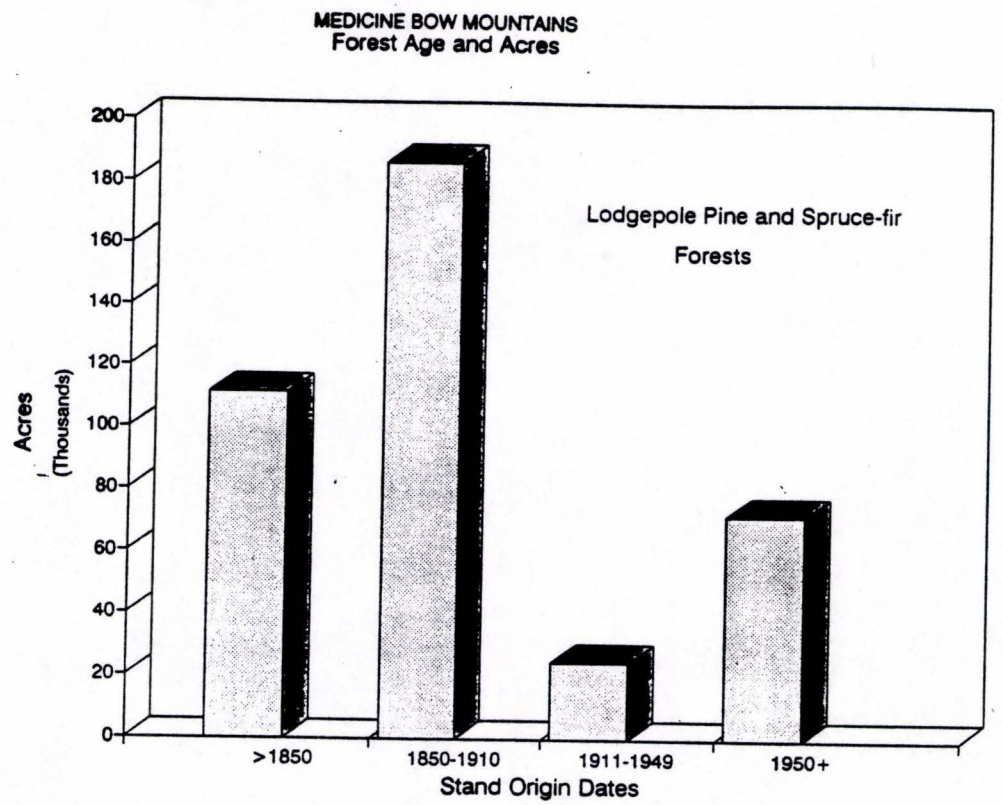


- 195 years old and older (year of origin <= 1799)
- 145 through 194 years old (year of origin 1800-1849)
- 84 through 144 years old (year of origin 1850-1910)
- 45 through 83 years old (year of origin 1911-1949)
- 44 years old and younger (year of origin >= 1950)
- No age data forested
- No age data other (openings, State, Private, water)

- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, age_sierra.aml



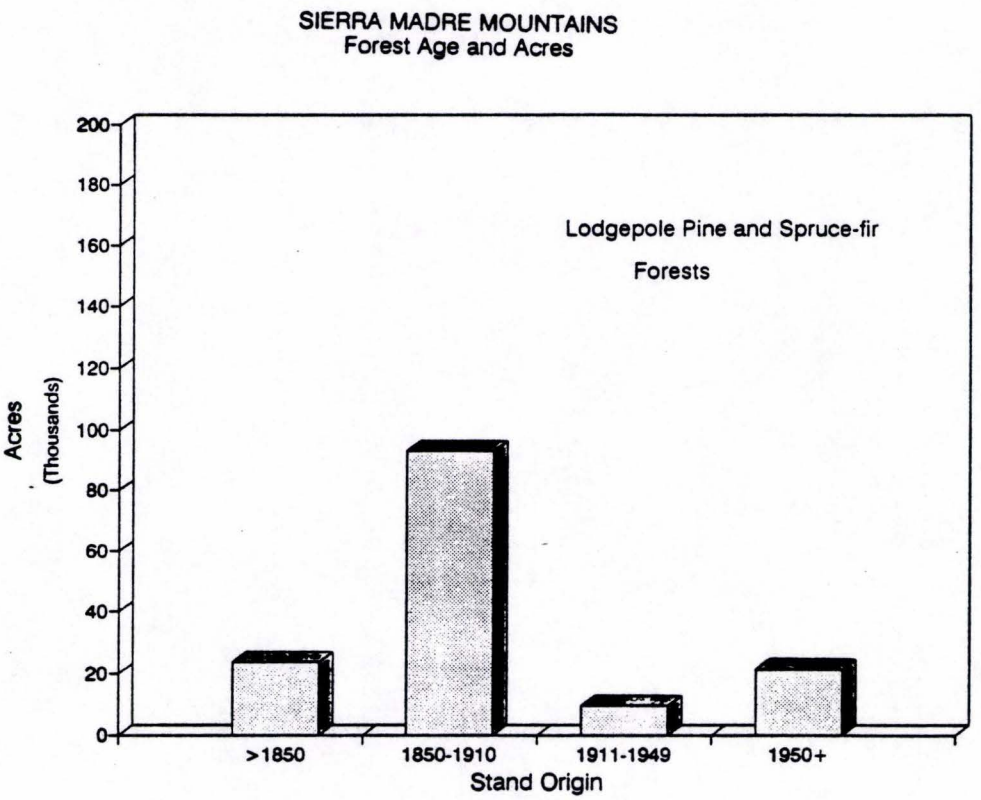


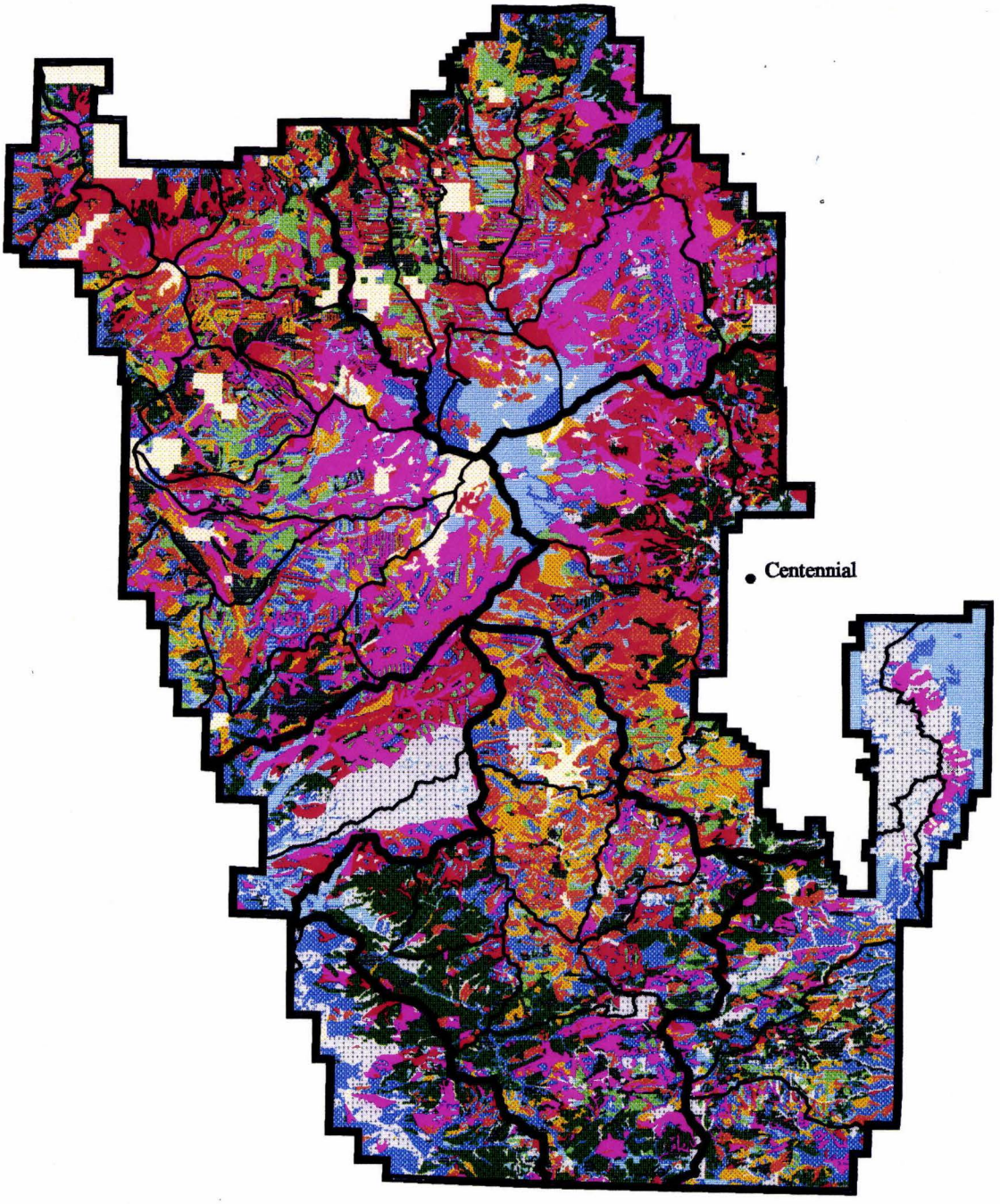
FIGURE 6-30 Acres of forest by age category for the Sierra Madre and Medicine Bow mountains. Source- RIS database.

MEDICINE BOW NATIONAL FOREST

Habitat Structural Stage Map

SNOWY RANGE

FIGURE 6.31a



Created by CLT for JVA, 01/11/95, hss snowy.aml

LEGEND

- 1 Grass/Forb
- 2 Shrub/Seedling
- 3A Sapling/Pole
- 3B Sapling/Pole
- 3C Sapling/Pole
- 4A Mature
- 4B Mature
- 4C Mature
- 5 Old, Large, Closed Canopy
- Forested, no data
- Other, no data (openings, State, Private, water)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

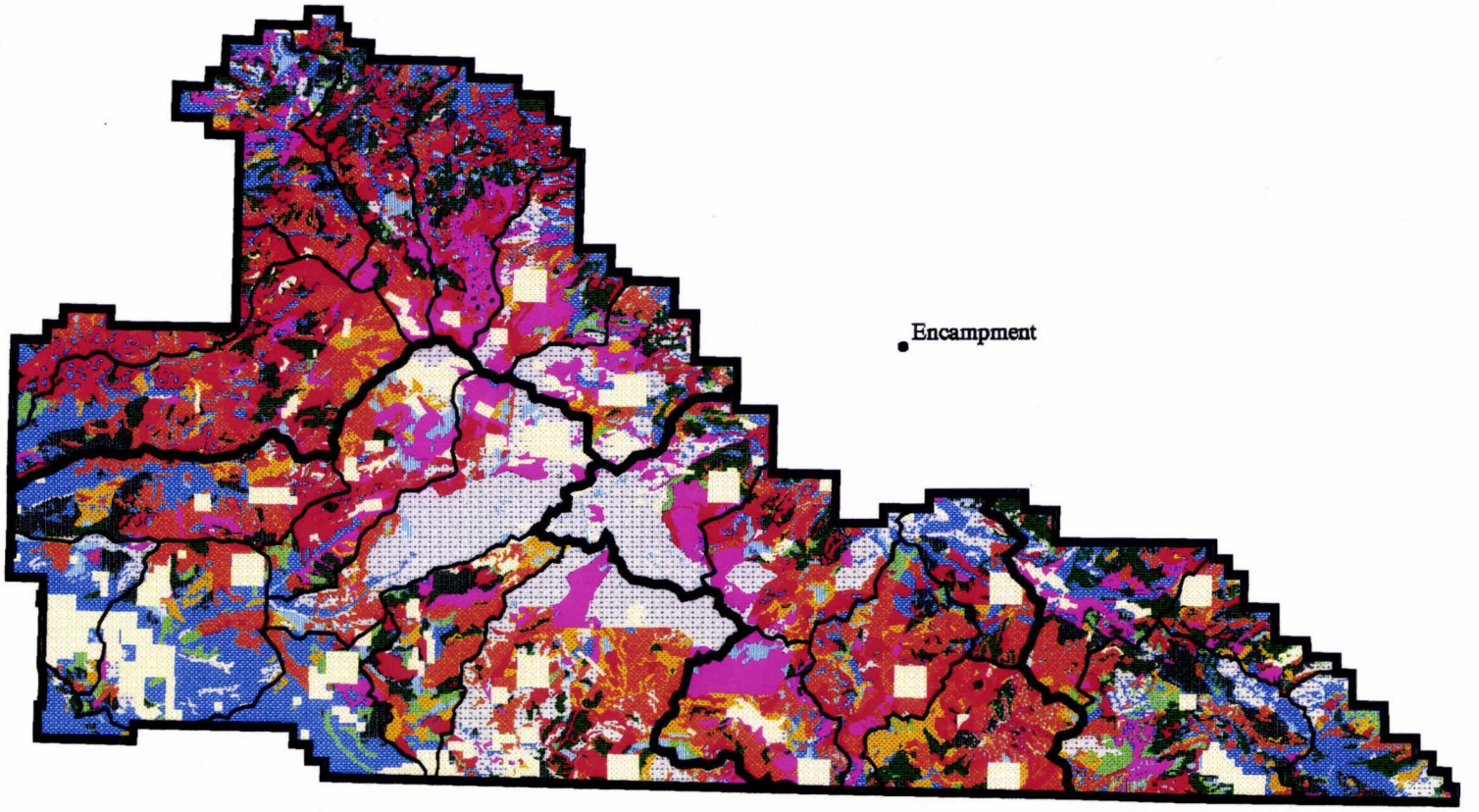
Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Habitat Structural Stage Map

SIERRA MADRES

FIGURE 6.31b



LEGEND

- 1 Grass/Forb
- 2 Shrub/Seedling
- 3A Sapling/Pole
- 3B Sapling/Pole
- 3C Sapling/Pole
- 4A Mature
- 4B Mature
- 4C Mature
- 5 Old, Large, Closed Canopy
- Forested, no data
- Other, no data (openings, State, Private, water)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

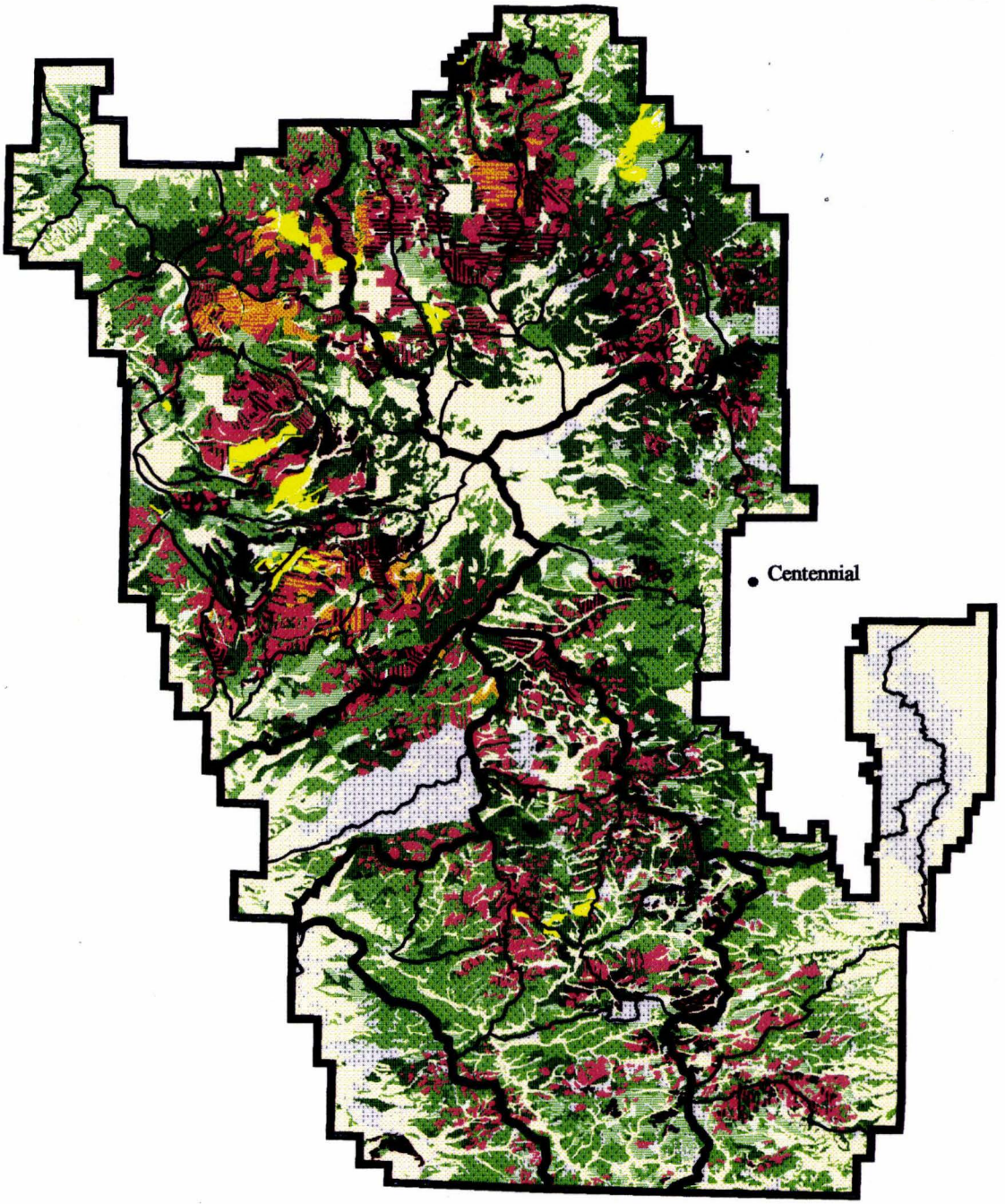
Created by CLT for JVA, 01/11/95, hss_sierra.aml

MEDICINE BOW NATIONAL FOREST

Vegetation Disturbance Map

SNOWY RANGE

FIGURE 6.32a



Created by CLT for JVA, 01/26/95, dist_snowy.aml

LEGEND

Forested, undisturbed since 1950

- Year Origin <= 1849
- Year Origin 1850 - 1909
- Year Origin 1910 - 1949
- Year Origin >= 1950

Forested, disturbed since 1950

- Partial Cut
- Group Shelterwood
- Clearcut
- Fire/Blowdown

Other

- Forested, no age data
- Non Forested, State, PVT
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Vegetation Disturbance Map

SIERRA MADRES

FIGURE 6.32b

LEGEND

Forested, undisturbed since 1950

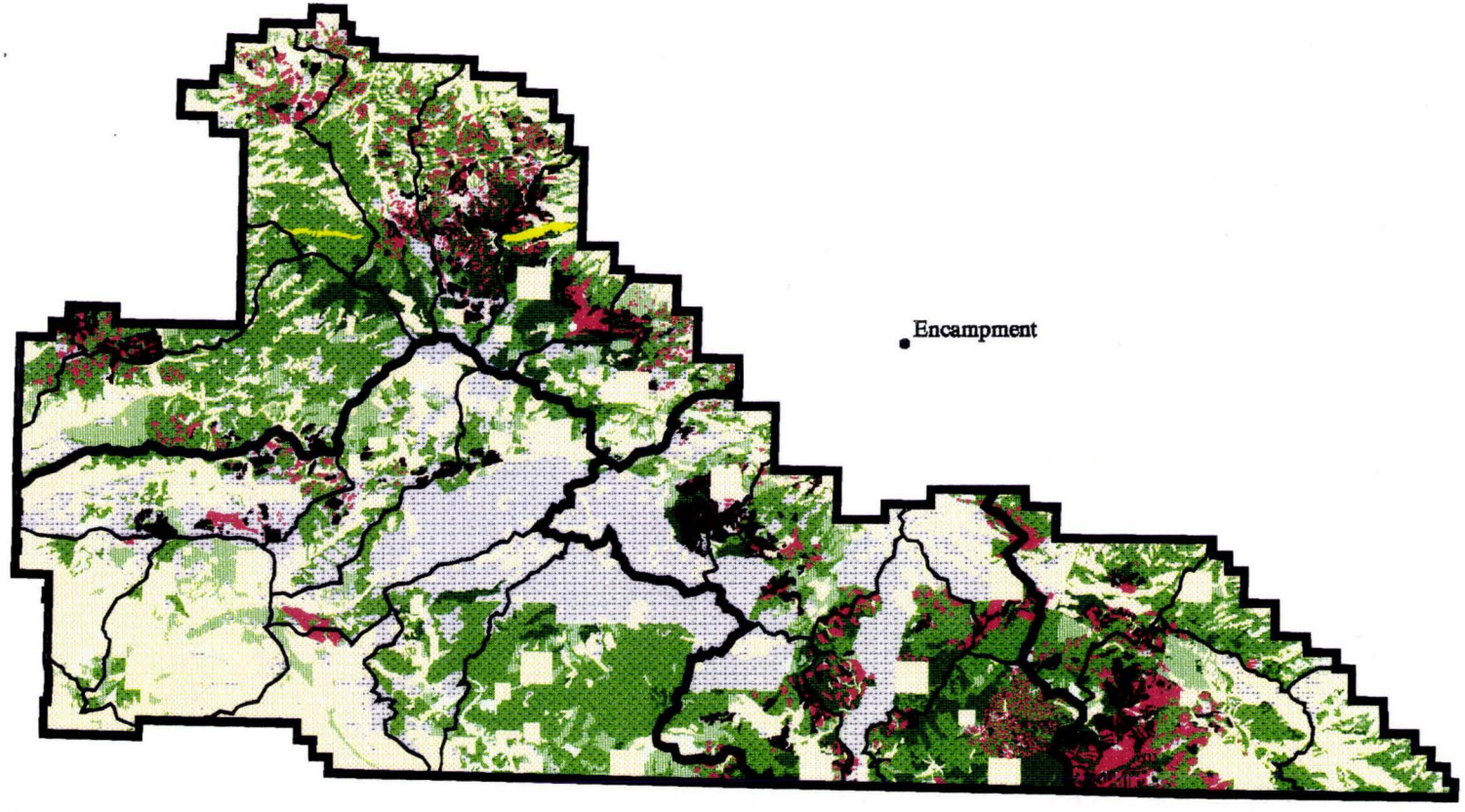
- Year Origin <= 1849
- Year Origin 1850 - 1909
- Year Origin 1910 - 1949
- Year Origin >= 1950

Forested, disturbed since 1950

- Partial Cut
- Group Shelterwood
- Clearcut
- Fire/Blowdown

Other

- Forested, no age data
- Non Forested, State, PVT
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

Created by CLT for JVA, 01/26/95, dist_sierra.aml

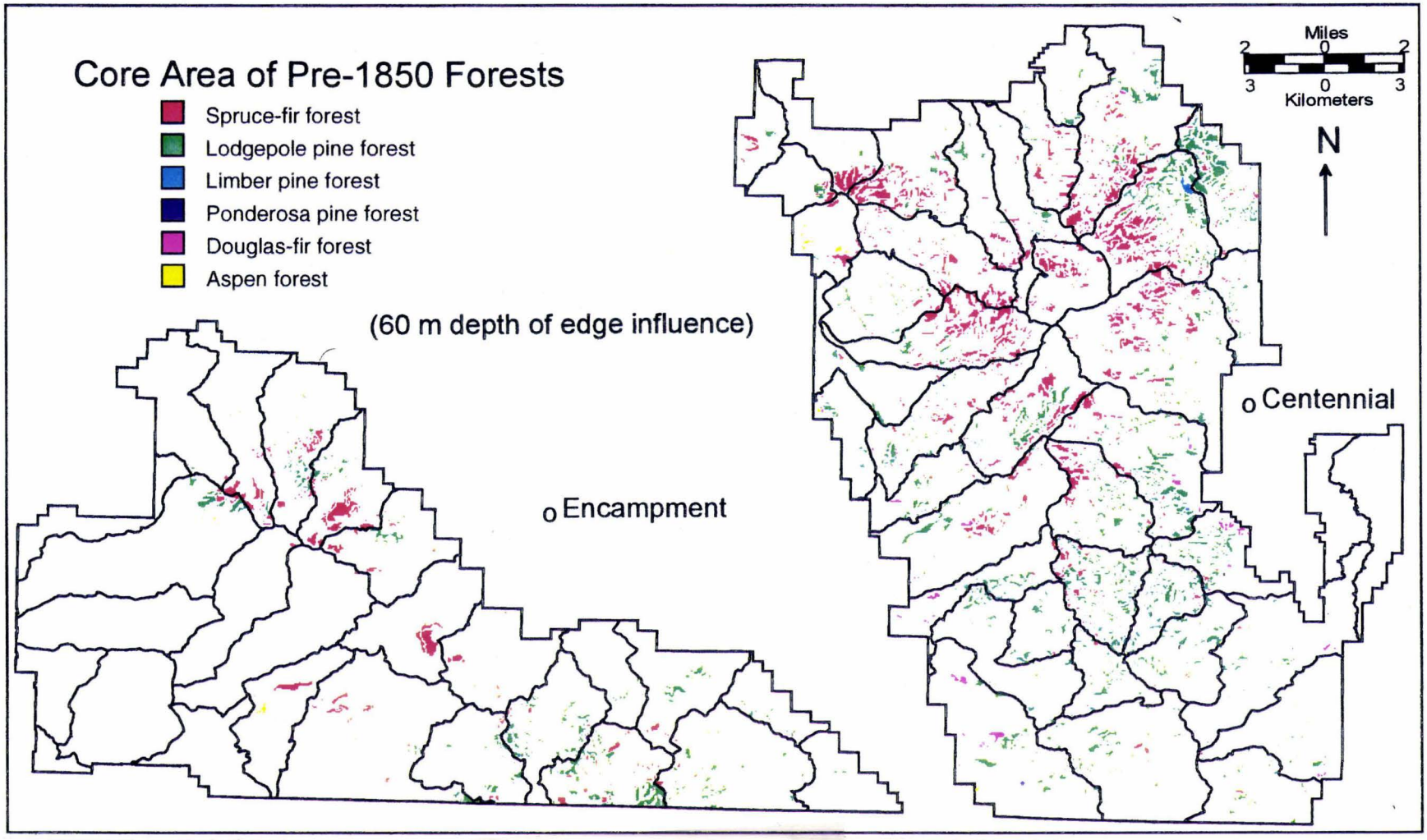


Figure 6.33 Interior areas of forest patches originating before 1850. (Baker 1994)
Data incomplete for Huston Park, Savage Run and Encampment River Wilderness areas.

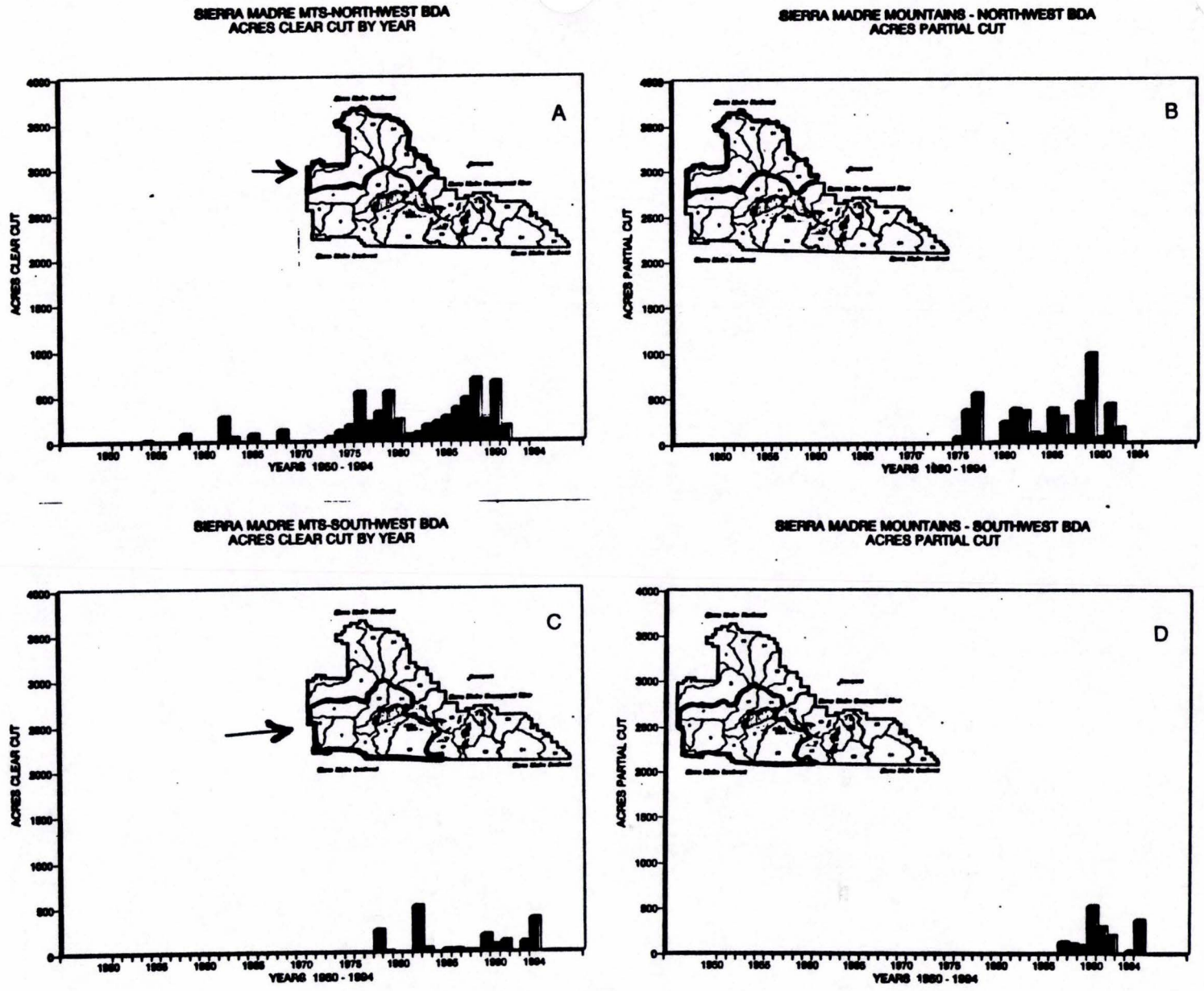


FIGURE 6.34 Sierra Madre Mountains Biodiversity Analysis Areas. Acres clear cut by year in 6.34 a,c. Acres partial cut by year in Figures 6.34 b,d. Group shelterwood cuts are included in partial cut acreage figures.

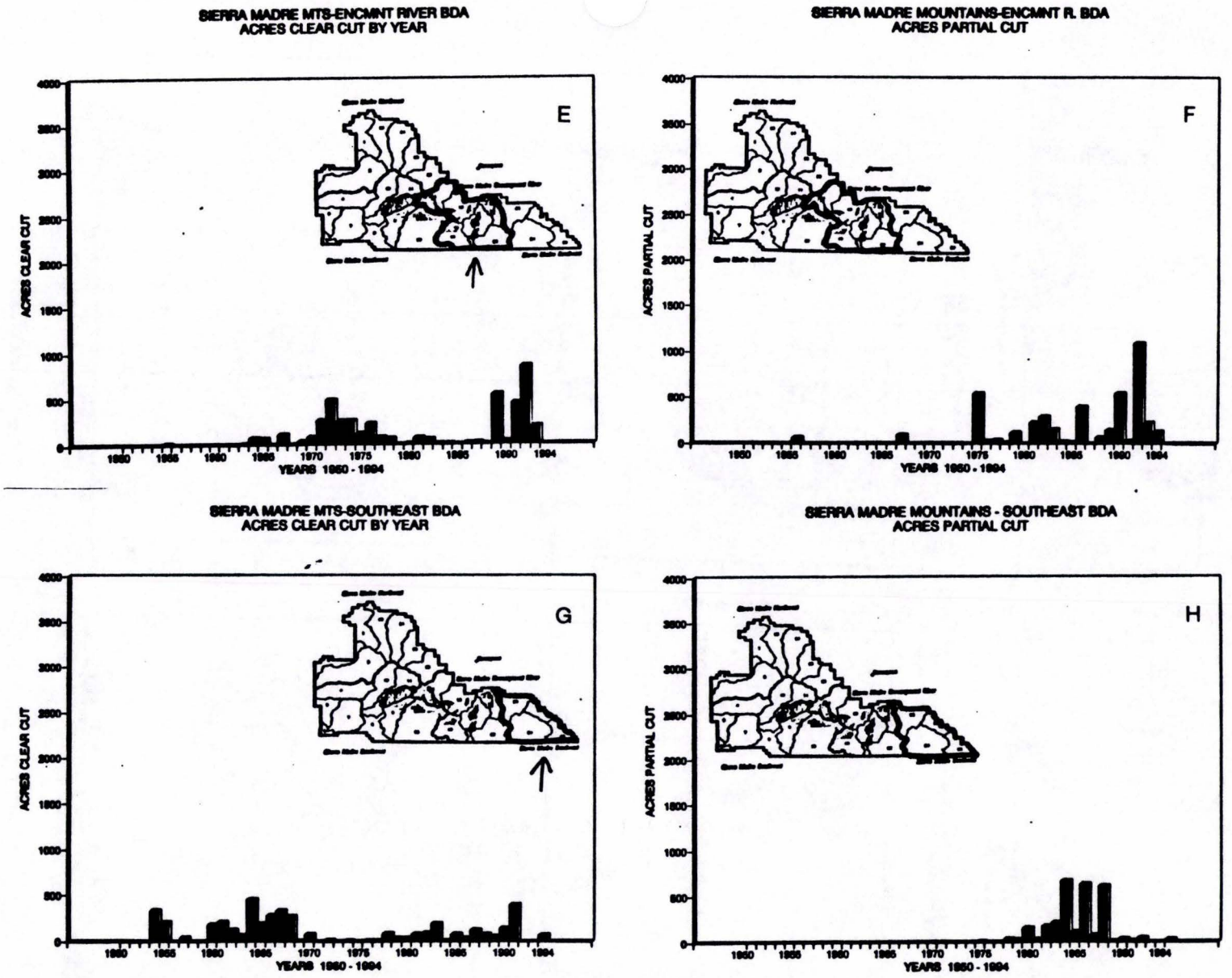


FIGURE 6.34 Sierra Madre Mountains Biodiversity Analysis Areas. Acres clear cut by year in 6.34 e,g. Acres partial cut by year in Figures 6.34 f,h. Group shelterwood cuts are included in partial cut acreage figures.

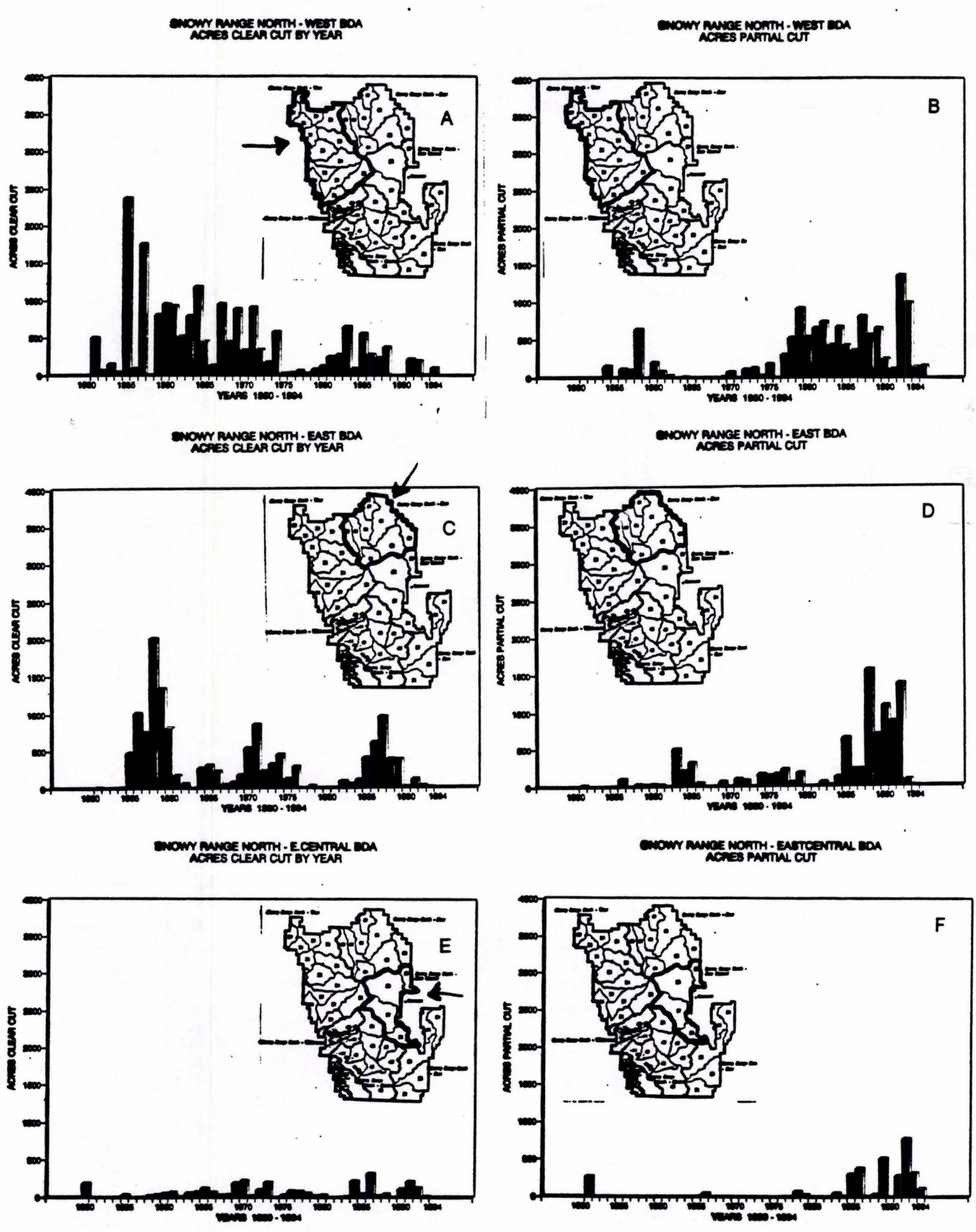


FIGURE 6.34 Medicine Bow Mountains Biodiversity Analysis Areas. Acres clear cut by year in 6.34 a,c,e. Acres partial cut by year in Figures 6.34 b,d,f. Group shelterwood cuts are included in partial cut acreage figures.

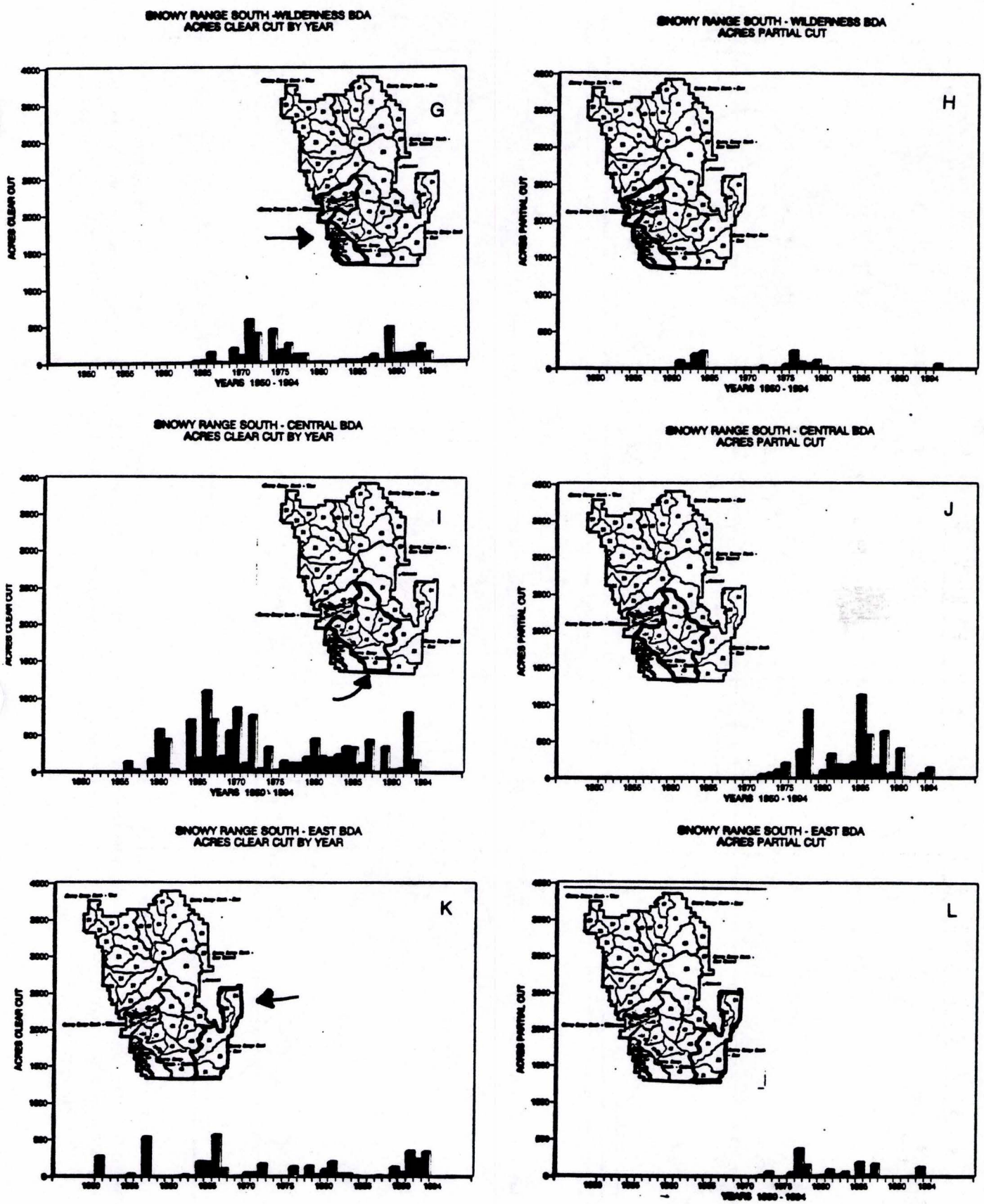


FIGURE 6.34 Medicine Bow Mountains Biodiversity Analysis Areas. Acres clear cut by year in 6.34 g,i,k. Acres partial cut by year in Figures 6.34 h,j,l. Group shelterwood cuts are included in partial cut acreage figures.

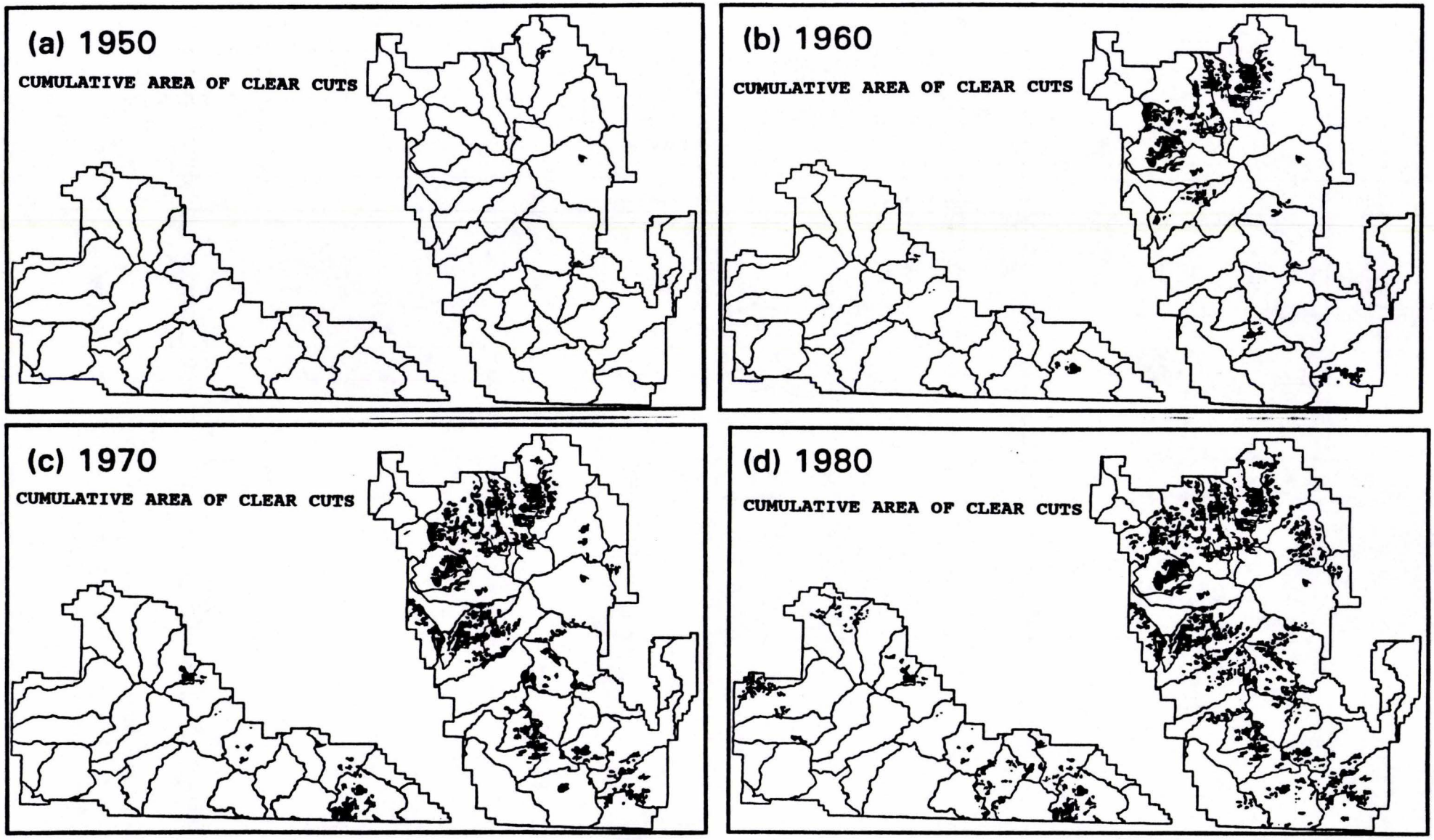
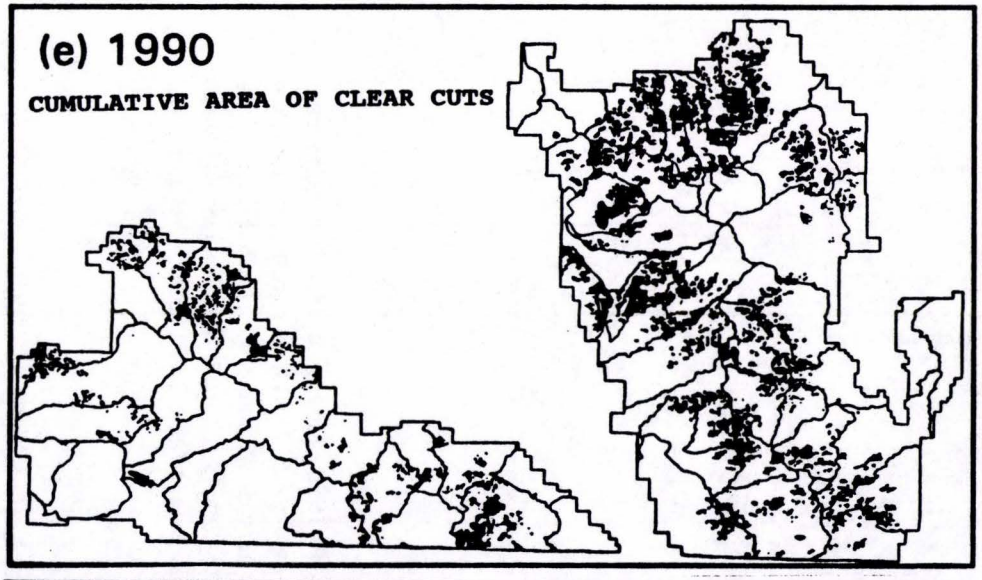
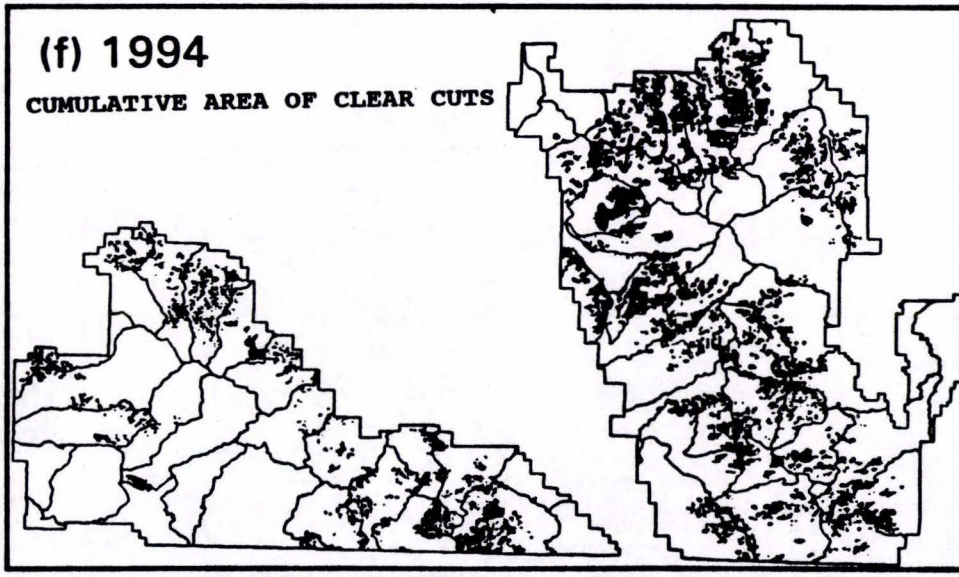
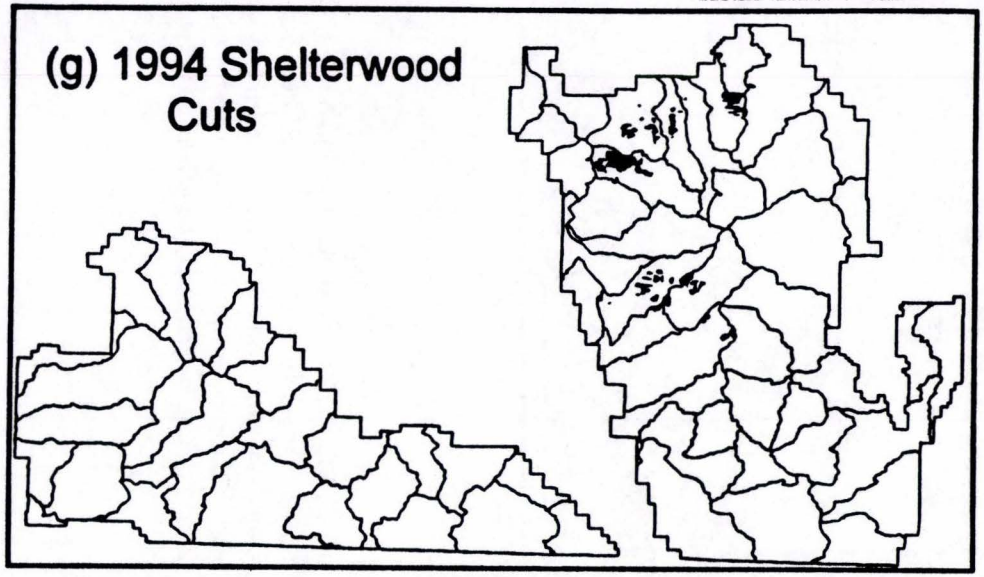


FIGURE 6.35 Cumulative areas harvested 1950-1990. Figures 6.35 a-f are clearcuts only. Figures 6.35 g and h are shelterwood and partial cuts. Figures 6.35 i shows cumulative areas affected by all types of timber harvest with no edge effect. Figure 6.34j shows the area affected if a 60 meter edge effect zone is included around clear cut areas in addition to partial cuts and group shelterwood cuts (Baker 1994, Figures 9 and 10).







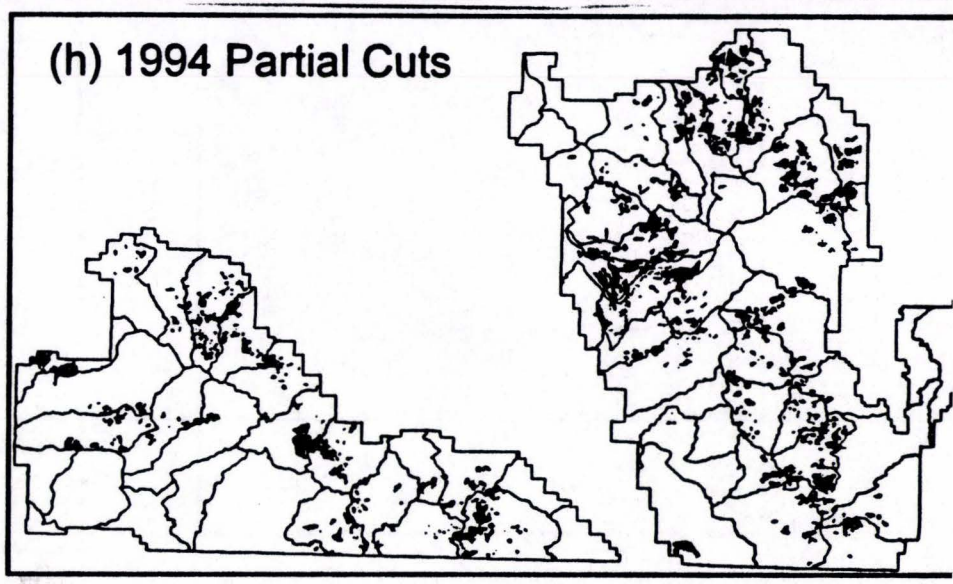
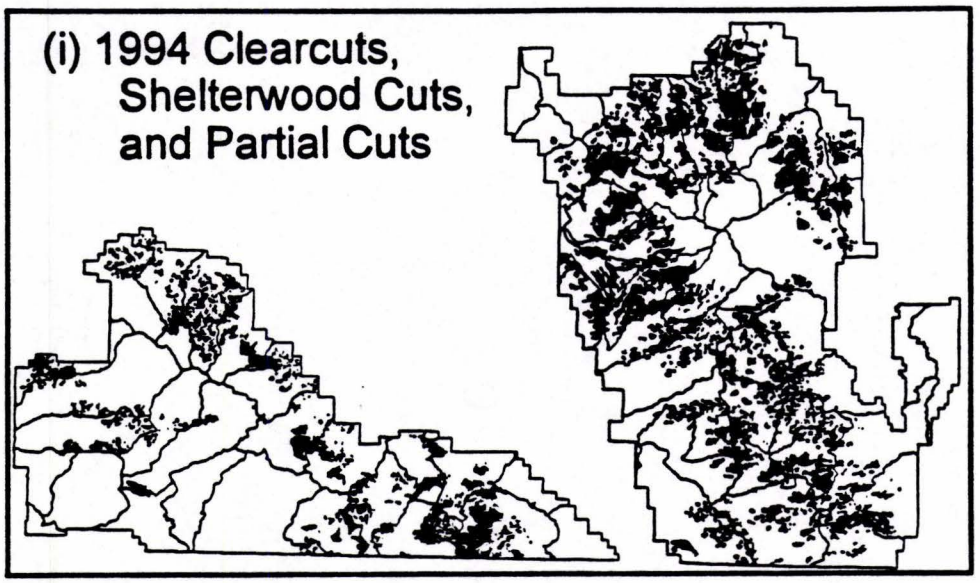


FIGURE 6.35 Cumulative areas harvested 1950-1990. Figures 6.35 a-f are clearcuts only. Figures 6.35 g and h are shelterwood and partial cuts. Figures 6.34 i shows cumulative areas affected by all types of timber harvest with no edge effect. Figure 6.35 j shows the area affected if a 60 meter edge effect zone is included around clear cut areas in addition to partial cuts and group shelterwood cuts. (Baker 1994, Figures 9 and 10).



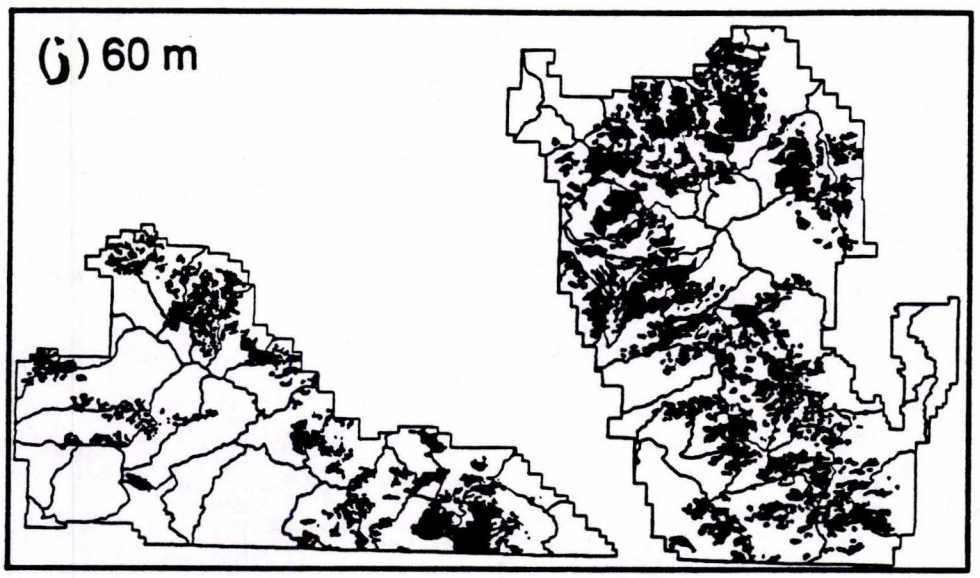


FIGURE 6.35 Cumulative areas harvested 1950-1990. Figures 6.35 a-f are clearcuts only. Figures 6.35 g and h are shelterwood and partial cuts. Figures 6.35 i shows cumulative areas affected by all types of timber harvest with no edge effect. Figure 6.34j shows the area affected if a 60 meter edge effect zone is included around clear cut areas in addition to partial cuts and group shelterwood cuts. (Baker 1994, Figures 9 and 10).

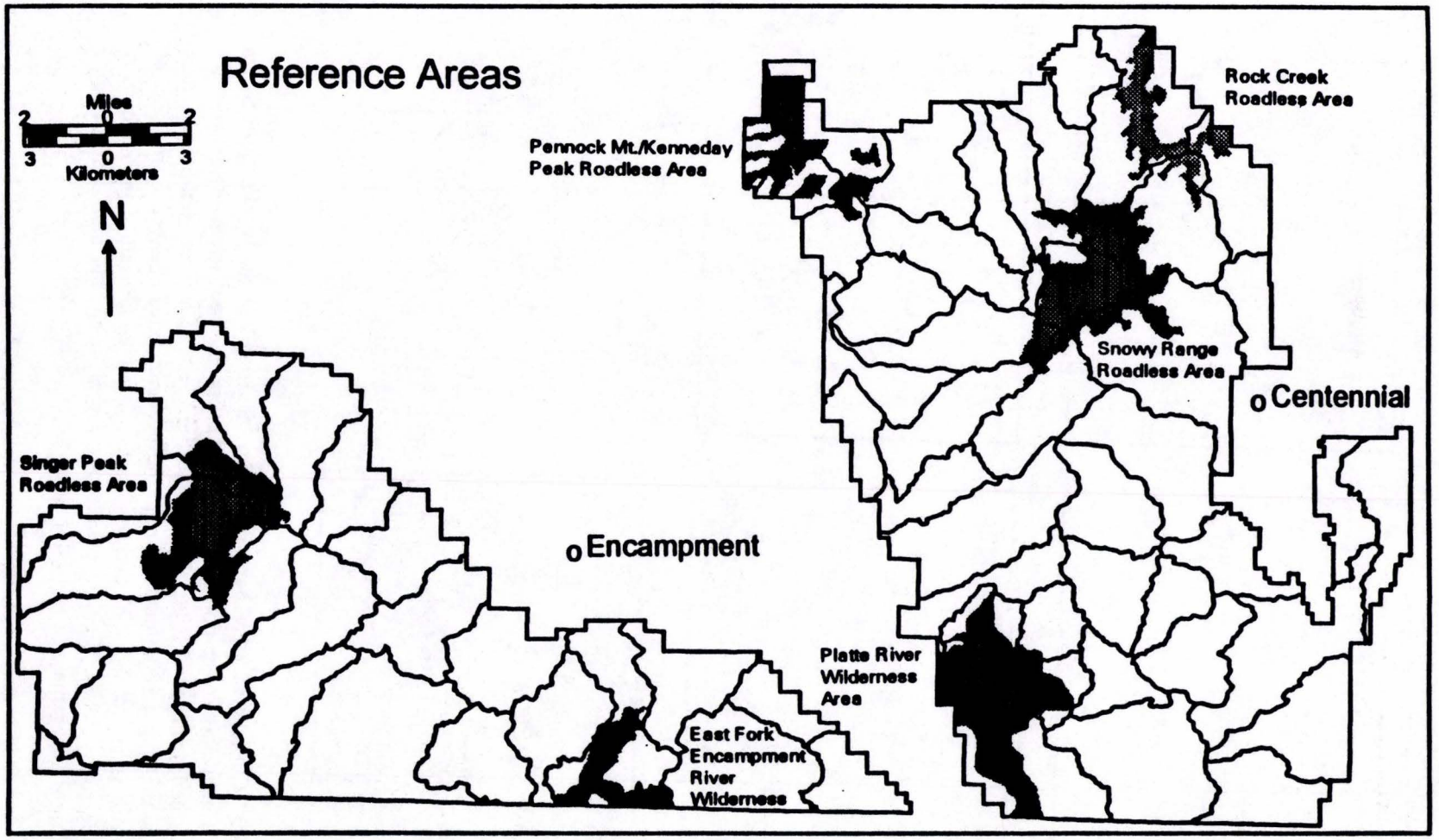


FIGURE 6.36 Reference areas used for landscape measurements to compare means for estimating watersheds in relation to estimated "range of natural variation" characteristics. (See Baker 1994). Reference areas are located in roadless areas.

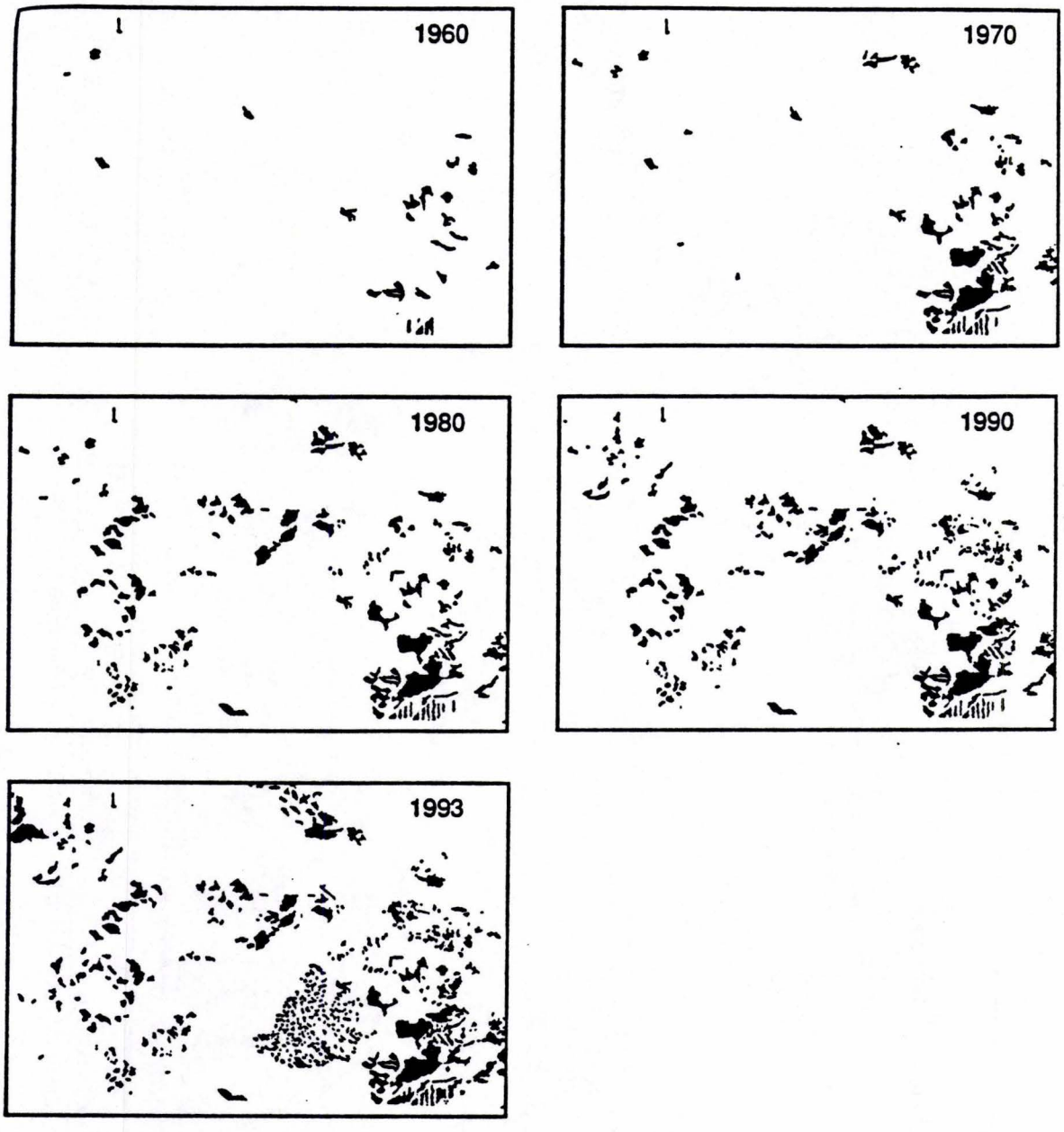


FIGURE 6.37 Cumulative areas harvested from 1960-1993 in the southeastern Sierra Madre (Tie Camp Area). The polygon includes the Encampment River Wilderness, the East Fork of the Encampment River, Coon Creek and parts of adjacent watersheds (Reid et al, in press). Using a 100m depth-of edge influence the area changed from about 40 percent interior forest to about 25 percent interior forest as a result of the addition of about 500 clearcut patches. Clearcut patches are regenerating, but high-contrast edges with uncut forest will remain in effect for many years. From Reed et al. (1996)

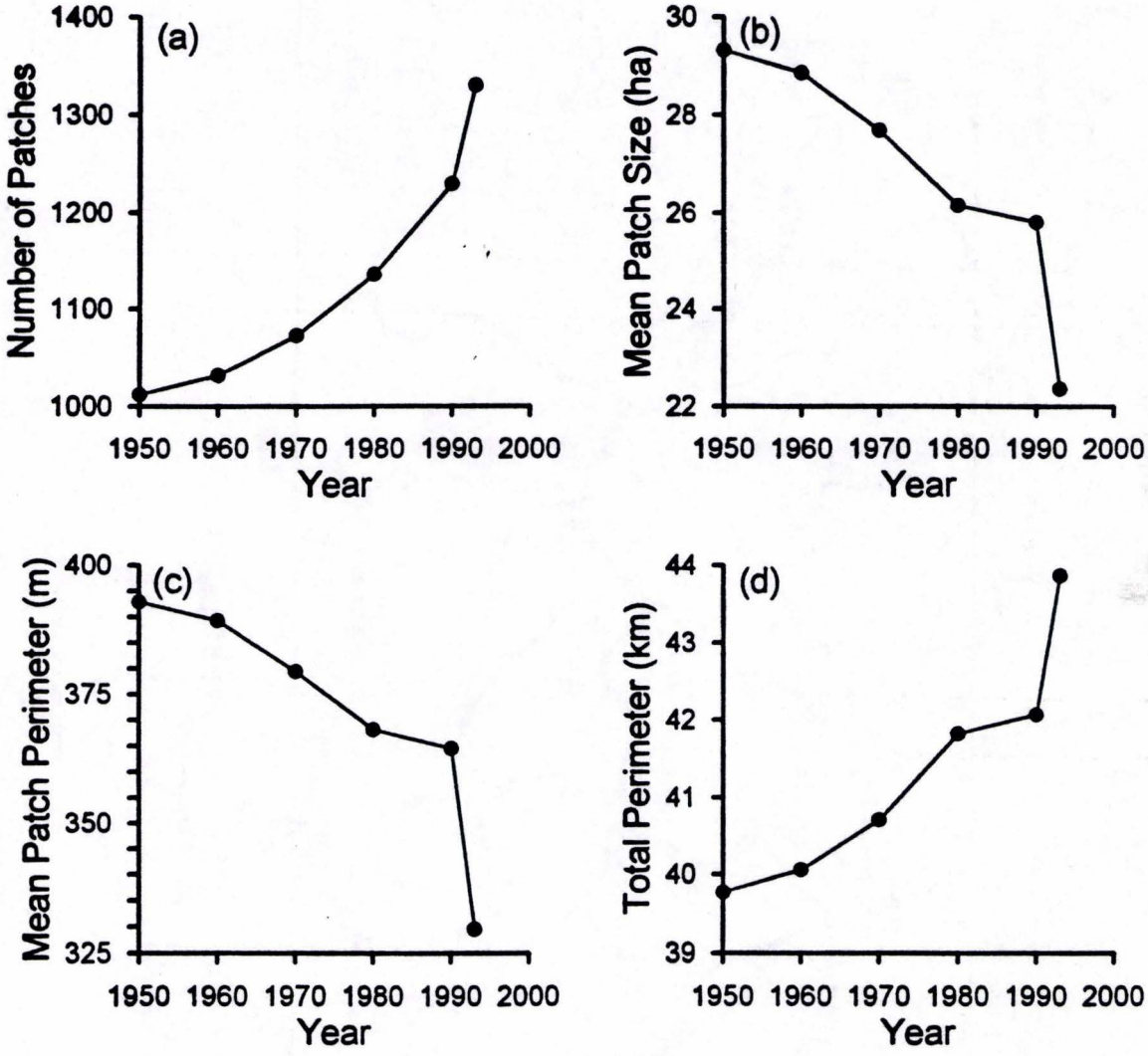


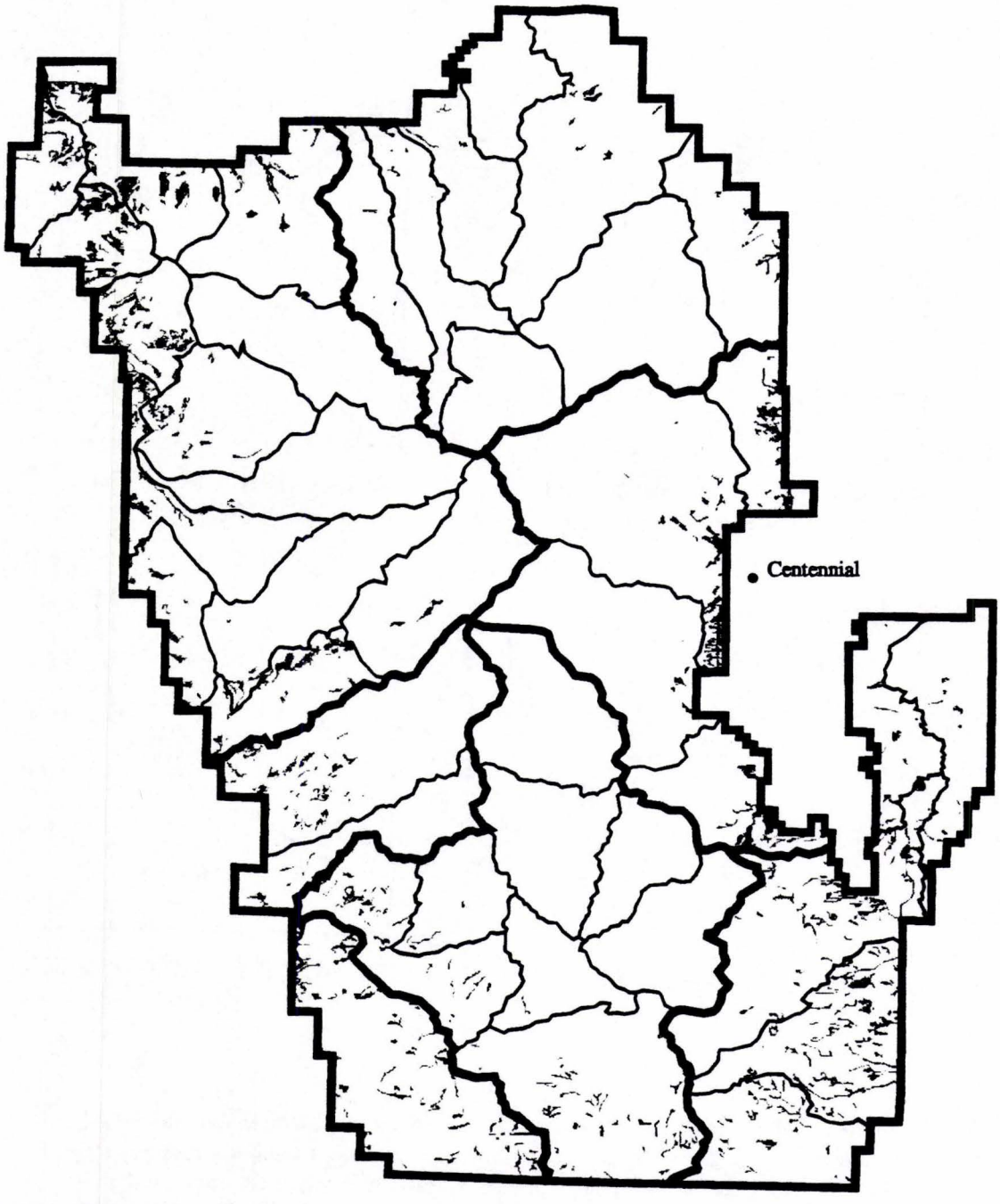
FIGURE 6.38 Graphs of cumulative number patches, patch size, average amount of edge and total amount of edge for clearcut patches intersected with a habitat structural stage map for the Tie Camp area. Number of patches and total perimeter increased while average amount of edge of average patch size decreased. Much of this effect is due to the small clearcuts in the Coon Creek Experimental Area (the Coon Creek effect). These graphs do not include effects of roads because data was unavailable at the time of analysis. From Reed et al.(1996).

MEDICINE BOW NATIONAL FOREST

Aspen Cover Type Location Map

SNOWY RANGE

FIGURE 6.39a



Created by CLT for JVA, 01/20/95, tss snowy.aml

LEGEND

Aspen

Biodiversity Unit Boundary

Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL REST

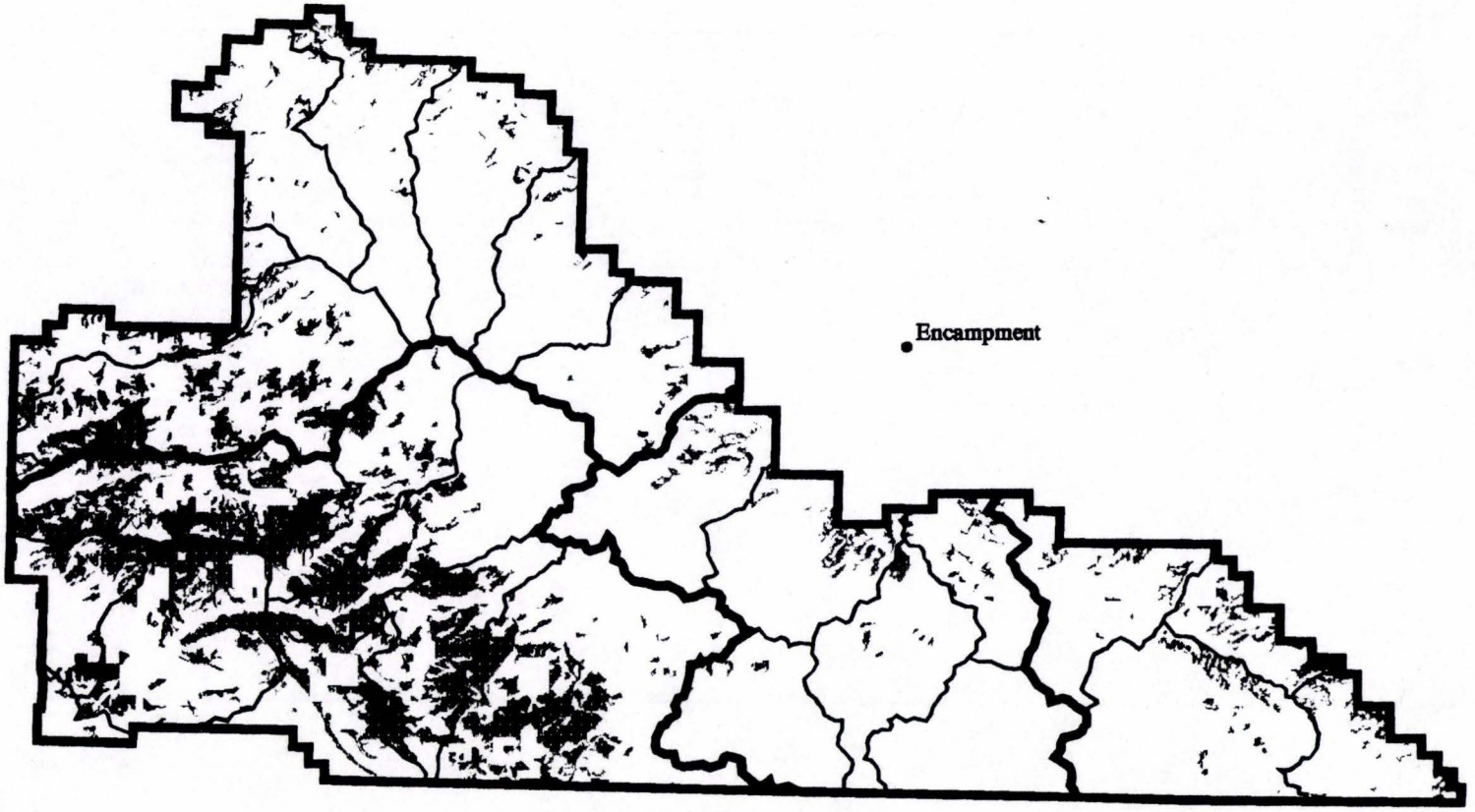
SIERRA MADI

Aspen Cover Type Location Map

FIGURE 6.39b

LEGEND

Aspen



Biodiversity Unit Boundary

Biodiversity Area Boundary

Scale 1 to 375,000

Created by CLT for JVA, 01/20/95, taa_sierra.aml

CHAPTER 7

AQUATIC AND RIPARIAN ECOSYSTEMS

INTRODUCTION

Conservation issues over loss of species and habitat have largely focused on terrestrial ecosystems such as the old growth forests in the Pacific Northwest. In recent years, more attention has been placed on aquatic ecosystem concerns. In North America, only two percent of the total stream miles in the contiguous 48 states remains in good condition (Williams and Rinne 1992). The American Fisheries Society (AFS) reported a 45 percent increase in the number of fish species in jeopardy due to the degradation of aquatic systems in North America over the past decade (Williams and Neves 1992).

Maintenance of biological diversity in aquatic systems has increasingly become an area of great interest and concern. The American Fisheries Society (AFS) has identified federal lands as the best hope for maintaining at least a portion of the aquatic diversity in the United States and identified steps for maintaining or improving it. These steps take into consideration the natural processes that have worked to form aquatic habitats and how these processes are affected by the activities of man.

Management of multiple use lands for biological diversity and ecological integrity will provide a framework for solving the problems facing our aquatic resources (Williams and Rinne 1992). To attain long-term sustainability of public resources (terrestrial and aquatic), AFS recommended that the following elements be addressed:

> The primary goal must be ecosystem integrity. For aquatic systems, it is necessary to maintain the integrity of the entire watershed.
>
> Planning must be on an ecosystem or a watershed basis.
>
> Management programs should be based on an ecosystem approach and recognize the interconnectedness of ecosystems.
>
> Management programs should consider ecosystem processes. For aquatic ecosystems these include processes such as energy, waterflow, and nutrients. Aquatic systems evolved with processes that must be allowed to continue.

Management programs should be continually evaluated and modified, based on new information.

Fifty-two eighth-level watersheds have been identified on the MBNF as "watersheds of concern" because of a high degree of channel instability and/or watershed disturbance or water quality deficiences which affect watershed health or biological diversity. Watershed instability was either due to natural inherent instablity (i.e. extensive landslides, highly erosive soils) or forest management activities or a combination of the two.

Headwaters of parts of the North Platte, South Platte and Little Snake River drainages are found on the MBNF. Mountain areas of the MBNF are a major contributor of water to the North Platte and Little Snake Rivers. Major sources of non-point source pollution (some of which are not on NFS lands) are pastureland, rangeland, and flow alteration in the North Platte River and Little Snake River drainages. Major sources of non-point pollution in the South Platte drainage are hydrological modifications such as flow alteration and filling of wetlands.

Major aquatic ecosystems on the MBNF include high mountain lakes, moraine ponds, reservoirs, high elevation streams, and major foothills streams such as the North Platte River. Phytoplankton, zooplankton, macroinvertebrate, and fish communities have been described for several of the aquatic ecosystems on the forest. Most streams on the forest are dominated by clean-water taxa indicating good water quality and good instream substrate conditions. Information concerning substrate use by macroinvertebrates has also been determined for selected streams on the MBNF.

Ten fish species are considered indigenous. Nine non-native fish species have been introduced. Introduction of non-native (exotic) species has increased fish species diversity on the MBNF but has has reduced ecological integrity because of negative effects on indigenous fish populations, especially Colorado River cutthroat trout. Predation in the high mountain lakes of the Snowy Range Mountains likely has contributed to the decrease in amphibian populations.

Riparian areas are varied. Extensive areas of wet forblands and meadows are found above timberline in the Medicine Bow Mountains. Along high-gradient streams at upper elevations riparian vegetation is primarily spruce-fir forest. At mid-elevations, lodgepole pine interspersed with willow flats becomes more evident. Willow, willow and aspen, or cottonwood and willow communities occur at lower elevations in the Sierra Madre Mountains, Sherman Hills, and Laramie Mountains. Canyons provide a special environment for riparian vegetation communities.

Changes to riparian areas include:

1. Lowered water tables and changed vegetation due to removal of beavers.

2. Alteration of riparian vegetation resulting from historical tie drives. Removal of large trees during the tie drives created relatively young, even-aged stand of trees. Restoration of riparian ecosystems is dependent upon the growth of large trees in the riparian zone and their eventual recruitment into the streams as coarse woody debris.

3. Alteration of riparian vegetation and stream channels from past and present grazing, especially on the west side of the Sierra Madre Mountains and in the Laramie Mountans.

4. Changes to aquatic and riparian areas caused by management activities such as road construction, timber harvesting, and grazing. While not widespread, the effect of these activities is cause for concern in some watersheds.

5. Alteration of aquatic communities in Haggerty Creek and Bear Creek from point source pollution. Haggerty Creek has been identified by the Wyoming Department of Environmental Quality as the most severely affected creek from point source pollution in the state.

6. Alteration of natural flow regimes and riparian vegetation due to water diversions and sediment spills which change habitat characteristics. Diversion of water from natural stream courses on the Forest has lowered water tables and altered riparian vegetation. These impacts occur primarily in the foothills areas of the Forest.

7. Alteration of high-elevation riparian communities due to past timber harvesting around kettleholes in the northern Snowy Range.

8. Proliferation of exotic noxious weeds in many lower elevation riparian areas.

Documentation of these problems is found throughout this chapter and in Appendices 13 and 14.

CHARACTERISTICS OF AQUATIC ECOSYSTEMS

DISTURBANCE PROCESSES

Physical and chemical features of an ecosystem provide the framework within which an ecosystem develops. Productivity is largely due to temperature and nutrient type and availability. Physical habitat is determined mainly by adjacent hill slopes and riparian vegetation (Sullivan et al. 1987). Factors that control stream channel morphology are discharge, sediment load, and physical features in the channel (i.e. large wood and rocks, bank characteristics). Flowing water works within the surrounding landscape to change various aquatic habitats. Most of the time stream channels are in a state of dynamic equilibrium, where the amount of sediment recruited into the channel is equal to the amount of sediment transported out of the system.

Catastrophic events such as landslides and wildfire can influence the hydrology, water chemistry, and geomorphology of aquatic ecosystems (Schullery et al. 1994). These effects can be long-term, requiring literally hundreds of years for complete system recovery (Swanston, 1991). Human activities can affect natural processes and the frequency, magnitude, and duration of major catastrophic events. Important natural processes, their approximate range or recurrence, and their impact on channel and habitat conditions are shown in Table 7.1.

Effects of processes on habitat quality and productivity depend on the intensity and timing of disrupting events (Swanston 1991). Some events occur on a regular basis and are generally easy to predict (seasonal and annual precipitation, moderate streamflows, etc.). Other events occur less frequently, are more sporadic, and thus are more difficult to predict. Large unpredictable events are usually triggered by major storms, large scale vegetation disturbances (i.e. fire, windthrow, insects, and disease), or changes in the earth's crust (i.e. earth quakes, volcanic activity, etc.) (Swanston 1991). All events can alter watershed processes, local channel configuration, and composition of aquatic biota.

The magnitude of a disturbance will often determine the amount of change that occurs within a watershed. For example, during extreme flood events, organisms find refuge behind logs and among roots and flooded vegetation. This behavioral adaptation has been documented in high altitude streams in the Snowy Range (Kimble and Wesche 1975). Extreme flood events, while relatively short-lived, can alter the habitat and behavior of aquatic organisms. Effects on stream channels of large-area wildfires in Yellowstone National Park, 1988, included sudden changes in channel morphology as a result of increases in flow, sediment, and debris (Bozek and Young 1994; and Gibbons and Salo 1973). Increases in sediment concentrations can have lethal effects on fish populations (Bozek and Young 1994).

Table 7.1. Approximate ranges of recurrence intervals for major disrupting events and their the effects on hydrological processes, habitat conditions, and channel geomorphology (modified from Swanston 1991; Sales 1990; Fressell et al. 1986).

Event	Recurrence	Hydrological Process	Channel/Habitat Considerations
Tectonics, major climate and eustatic change	>10,000 yr	Evolution of basins channel evolution	Creation of watersheds, major changes in channel direction, formation of lakes, grade, and configuration, valley formation of aquifers, broadening or incision, alteration of flow regime, creation of stream networks.
Slumps and earthflows	100-10,000 yr	Channel pattern, landscape erosion, flow nets and linkages	Long-term contribution of sediment and large woody debris to stream channels, partial blocking of channels, shifts in channel configuration, sediment deposition in pools, siltation of spawning and rearing habitat, increased summer water temperatures, decreased winter temperatures.
Major floods	100-10,000 yrs	Channel pattern, landscape erosion, flow nets and linkages	Major changes in channel configuration , increased movement of sediment and woody debris to channels, movement and redistribution of large trees, channel changes, increased large woody debris jams, scouring of stream channels, increased bank instability, filling and scouring of pools and riffles.
Insects and disease	Not known	Energy fluxes, landscape erosion, nutrient cycling	Increased sediment delivery to channels, loss of riparian vegetation cover, increased large woody debris in channels, decreased litterfall, increased sediment in spawning areas and filling of pools, increased summer temperatures, decreased winter temperature
Wildfires	Not known	Streamflows, energy fluxes, landscape erosion, channel scour and deposition, nutrient cycling	Increased sediment delivery to channels, increased large woody debris in channels, loss of riparian vegetation, increased channel flows, increased nutrient levels in streams, sedimentation in spawning areas and filling of pools, increased summer temperatures and decreased winter temperatures, decreased availability of fine woody debris, increased availability of food organisms.

Table 7.1. continued

Event	Recurrence	Hydrological Process	Channel/Habitat Considerations
Major disturbance of vegetation and windthrow nutrient cycling	10-100 yr	Streamflows, energy fluxes, landscape erosion, channel scour and deposition	Increased sediment delivery to channels, decreased litterfall, increased large woody debris in channels, loss of riparian cover, increased water yield, sedimentation of spawning habitat, increased summer temperatures and decreased winter temperatures, decreased fine organic debris.
Beaver	5-100 yr	Streamflows, energy fluxes	Channel damming, obstruction and activity redirection of channel flow, flooding of banks and side channels, siltation of gravels behind dams, increased water volume during low flow periods, increased pool habitat, slack water and back water refuge areas during floods, limitations on fish migrations, elevated water temperatures, local reductions in dissolved oxygen.
Major storms usually occurring in localized watersheds	1-10 yr	Energy fluxes, landscape erosion, channel scour and deposition	Increased movement of sediment and woody debris to channels, flood flows, local channel scour, movement and redistribution of coarse material, accelerated bank erosion, alteration of channel shape, changes in pool/riffle ration, filling and scouring of pools, siltation of spawning areas, formation of new aquatic habitats.
Seasonal ppt. and discharge, moderate storms, freezing and ice formation	.1-1 yr	Seasonal energy fluxes, nutrient cycling, streamflows, channel scour and deposition	Increase flow to bankfull width, moderate channel erosion, increased mobility of in channel sediment and woody debris, scouring of channel bed, flooding of side channel areas.

Over time these impacts may prove beneficial by increasing the amount of nutrients in sterile streams and thereby increasing the availability of food resources for fish and macroinvertebrates (Gibbons and Salo 1973).

Watershed sensitivity, to both minor and major disturbances, is subject to a broad range of variability. Some watersheds are highly sensitive to disturbance because of steep slopes and highly erodible soils. Other watersheds are more resilient and capable of accommodating extreme climatic events or more intense ground-disturbing activities.

WATERSHEDS OF CONCERN

Watersheds of concern were identified based upon criteria of inherent stability, channel conditions, water quality, and type and extent of management activities. Watersheds of concern are those which have the potential for aggravation of existing physical or chemical problems which can degrade watershed health. A detailed discussion of the analysis approach is in Appendix 14 (Watershed Health).

Fifty-two eighth-level watersheds on the MBNF have a high degree of physical instability or water quality deficiencies which affect watershed health and biological diversity characteristics (Figure 7.1; Table 7.2).

Criteria for identifying watersheds of concern are:

1. The presence of widespread poor channel conditions (aggradation or degradation).

2. The percentage of the watershed composed of active landslide areas.

3. Water quality that fails to meet state water quality standards.

4. Soil erodability, indicated by a Weighted Average K Factor.

5. Cumulative Disturbed Area Rating, based on an Equivalent Clearcut Acres (ECA).

Criteria 4 and 5 identify watersheds of concern based on the proportion of disturbed area within them. Watersheds with a cumulative disturbed area greater than 25 percent or a weighted average K factor greater than .35 were considered to be at risk from effects of cumulative disturbance.

TABLE 7.2. Eighth level watersheds of concern for the Medicine Bow National Forest.

Biodiversity Area	Fifth Level Watershed Name	Eighth Level Watershed Number	Gross Acres	NFS Acres	Reason(s) for Concern
Snowy Range Northeast	Rock Creek	1018000403010500	4,948	4,948	Overbank depsition/ unstable channel
	Rock Creek	1018000403010700	4,494	4,494	Equivalent clearcut acres >25%
	Bow River	1018000401010105	2,042	2,042	Overbank deposition/ unstable channel
	Bow River	1018000401010301	1,844	1,844	Equivalent clearcut acres >25%
	Bow River	1018000401010302	2,092	2,092	Equivalent clearcut acres >25% / unstable channel
	Bow River	1018000401010304	2,499	2,499	Equivalent clearcut acres >25%
	Fourmile Creek	1018001008010100	6,791	2,535	Extensive landslides present
	Fourmile	1018001008010401	6,134	2,116	Extensive landslides present
Snowy Range Northwest	Pass Creek	1018000220070000	8,749	1,810	Equivalent clearcut acres >25%
	Brush Creek	1018000207020400	1,535	1,535	Equivalent clearcut acres >25%
	French Creek	1018000205010200	1,383	1,383	Equivalent clearcut acres >25%
	French Creek	1018000205010401	1,327	1,327	Equivalent clearcut acres >25%
	French Creek	1018000205010402	1,106	1,106	Equivalent clearcut acres >25%
	French Creek	1018000205010300	4,581	4,581	Equivalent clearcut acres >25%

Table 7.2 **continued**

Biodiversity Area	Fifth Level Watershed Name	Eighth Level Watershed Number	Gross Acres	NFS Acres	Reason(s) for Concern
Snowy Range Northwest	French Creek	1018000205020600	1,248	1,248	Equivalent clearcut acres >25%
	Pass Creek	1018000220020000	3,567	3,374	Equivalent clearcut acres >25%
	Pass Creek	1018000220010300	1,833	1,833	Equivalent clearcut acres >25%
	Pass Creek	1018000220050100	2,105	1,838	Extensive landslides present
	Cedar Creek	1018000212010102	1,021	1,002	Overbank deposition/ unstable channel
	Cedar Creek	1018000212020600	2,730	1,508	Overbank deposition/ unstable channel
	Cedar Creek	1018000212020300	1,565	1,559	Unstable channel
	Cedar Creek	1018000212020100	1,424	1,424	Unatable channel/ extensive landslides present
	Cedar Creek	1018000212020200	1,321	1,321	Unstable channel/ extensive landslides present
	Brush Creek	1018000207010400	7,999	6,516	Overbank deposition/ extensive point bar formation
	Brush Creek	1018000207010200	1,482	1,482	Overbank deposition/ extensive point bar formation
	Brush Creek	1018000207010101	6,868	6,868	Overbank deposition/ extensive point bar formation
	Brush Creek	1018000207020300	3,089	2,974	Overbank deposition/ extensive point bar formation

Table 7.2 continued

Biodiversity Area	Fifth Level Watershed Name	Eighth Level Watershed Number	Gross Acres	NFS Acres	Reason(s) for Concern
Snowy Range Northwest	Brush Creek	1018000207010501	2,015	2,015	Equivalent clearcut acres >25%
	Brush Creek	1018000207010502	2,067	2,065	Equivalent clearcut acres >25%
Snowy Range Northeast-Central	Little Laramie River	1018001007050200	5,320	785	Extensive landslides present
	Little Laramie River	1018001007050102	4,039	2,300	Extensive landslides present
	Little Laramie River	1018001007050101	5,456	2,447	Extensive landslides present
	Little Laramie River	1018001007050103	4,379	471	Extensive landslides present
Snowy Range South-Central	Douglas Creek	1018000202010200	2,950	2,785	Overbank deposition/ point bar formation
	Douglas Creek	1018000202010300	1,256	879	Unstable channel
	Douglas Creek	1018000202010400	2,588	1,970	Point pollution/ unstable channel
	Douglas Creek	1018000202080102	1,236	1,236	Equivalent clearcut acres >25%
	Douglas Creek	1018000202050100	1,654	1,654	Equivalent clearcut acres >25%
Sierra Madre Southeast	Encampment River	1018000209020400	2,453	2,164	Unstable banks/ creation of point bars
Sierra Madre Northwest	Spring Creek	1018000213040202	2,126	2,126	Tailings piles/overbank deposition

Table 7.2 **continued**

Biodiversity Area	Fifth Level Watershed Name	Eighth Level Watershed Number	Gross Acres	NFS Acres	Reason(s) for Concern
Sierra Madre Southwest	Little Snake River	1405000301040202	1,129	1,129	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000301040104	1,327	1,327	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000301040103	2,381	2,381	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000301040106	977	924	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000301040109	1,939	1,911	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000301040105	1,550	1,550	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000301040107	2,116	2,094	Overbank deposition/ point bar formation/ altered stream flow
	Little Snake River	1405000302030300	1,171	68	Average weighted K factor >.35
	Cottonwood Creek	1405000302020200	2,258	1,760	Average weighted K factor >.35
	Cottonwood Creek	1405000302030200	891	512	Average weighted K factor >.35
	Battle Creek	1405000304030400	2,296	2,278	Average weighted K factor >.35
Sierra Madre Southwest	Battle Creek	1405000304030500	2,712	1,077	Average weighted K factor >.35

Widespread channel instability has been documented in 22 eighth-level watersheds ranging in size from 977 acres to 6,868 acres. Stream channel instability is due either to inherent instability or a combination of management activities and inherent instability. Specifics concerning known causes of channel instability can be found in the watershed descriptions in Appendix 13.

Haggerty Creek and Bear Creek in the Sierra Madre Mountains have consistently failed to meet water quality standards because of point source pollution from copper from the Rambler and Ferris-Haggerty mines (Gumtow 1994).

Nine watersheds have more than 30 percent of their area covered by active landslides. Five have weighted average K factors greater than .35. These watersheds range from 891 to 6,791 acres in size. Seventeen watersheds have high Cumulative Disturbed Area Ratings and range in size from 1,236 to 3,567 acres.

Identifying watersheds of concern communicates information about the potential for aggravation of existing conditions of instability, widespread disturbance or poor water quality. Identification of watersheds of concern does not prohibit management activities (i.e. timber harvest, road construction) in the watershed. Additional analysis of these areas should occur prior to implementing further ground-disturbing activities.

WATERSHED DELINEATION

Watersheds were delineated using the procedure developed in the 1970s by the U.S. Geological Survey (USGS) for the delineation of their Hydrological Unit Map series. This procedure divides the United States into major hydrologic basins or first-level watersheds. The major basins are further subdivided into successively smaller hydrologic units; first-level watersheds are subdivided into second-level watersheds, second-level into third-level watersheds, etc.(Seaber et al. 1987). At the scale of the National Forest, most watershed units are mapped at the fifth through eighth level.

The first four hierarchical levels, each described with a two-digit code, have been mapped nationwide. In the state of Wyoming, the USGS third-level watersheds were subdivided into 22 fourth-level watersheds. The third-level watersheds which encompass the Medicine Bow National Forest include the North Platte, South Platte, and Little Snake River drainages.

In 1994, the MBNF initiated efforts to subdivide the nationally mapped fourth-level watersheds into smaller watersheds (fifth through eighth-level) for use in Forest and project level planning. The watershed units used in the aquatic analyses are seventh-level or eighth-level watersheds ranging in size from 1,000

to 10,000 acres. The Biodiversity Units (BDUs) used in the terrestrial ecosystem analysis are fifth-, sixth-, or seventh-level watersheds. Biodiversity Areas (BDAs) are groups of smaller BDU watersheds. See Appendix 1 for a list of codes and names.

WATERSHED PROFILES

LITTLE SNAKE RIVER WATERSHED IN WYOMING

SIERRA MADRE MOUNTAINS (west of the Continental Divide)

Location

The Little Snake River Drainage is approximately 3,777 square miles in Wyoming. It originates in the Sierra Madre Mountains of Wyoming and Park Range of Colorado. The North, Middle, and South Forks of the Little Snake River in Wyoming combine to form the Little Snake River in Colorado. The river flows westerly along the southern border of Wyoming, past the towns of Baggs and Dixon. After flowing through Baggs, the river turns south and joins the Yampa River.

Topographic Diversity

Conifer and aspen woodlands dominate the high mountain areas of the watershed from 8,000 to 11,000 feet. The middle altitudes (6500 to 8,000 feet) are composed of mountain-shrub vegetation, consisting of sagebrush, aspen, willow, alder, Gambel oak, and juniper. Sagebrush dominated areas occur in parks at 6,000-9,000 feet elevation.

Climate

The climate of the Little Snake watershed varies from arid, nearly desert environments west of Craig, Colorado, to cold, moist alpine zones along the Continental Divide to the east. Average precipitation varies from more than 40 inches along the Continental Divide to less than 12 inches near the confluence of the Little Snake and Yampa Rivers.

Geology

Mountains in this river basin were formed in Late Cretaceous and early Cenozoic time by the folding of the earth's crust. In Eocene time, a shallow lake was formed southwest of the Sierra Madre Mountains. Marlstone and calcareous shales from this lake comprise the Green River Formation, while around its edges fluvial and deltaic deposits form the Wasatch Formation (USGS 1984). Virtually

all the rocks in the Little Snake River Basin basin are of sedimentary origin, except the Precambrian rocks that dominate the peaks of the Continental Divide in the Sierra Madre Mountains and Park Range. The Precambrian rocks are composed of quartzite, conglomerate, and shale.

Water Use

Water from the Little Snake River in Wyoming is primarily used for urban water needs, irrigation, oil and gas activities, and recreation. The watershed produces approximately 350,000 acre-feet of water annually. No current information is available concerning the magnitude of water uses occurring within the drainage. The State Water Commission is currently completing a third-party Environmental Impact Statement (EIS) for proposed dam construction in the Little Snake River drainage in Wyoming. This document should provide an up-to-date estimate of water uses in the drainage.

Water Quality

Major sources of non-point pollution in the Little Snake River drainage include pastureland and rangeland. Flow alteration can increase concentrations of pollutants. A total of 202 miles of stream in the Little Snake River in Wyoming are affected by non-point source pollution. Pollutants include sediment/silt, total dissolved solids, and salinity.

Sources of point pollution include industry; highway, road, and bridge construction; and petroleum production activity. A total of 121 miles has been affected by these activities or sources. The predominant pollutants include heavy metals (specifically copper from the Ferris-Haggerty mine on private lands within the Medicine Bow National Forest), sediment and silt, total dissolved solids, and salinity.

Watershed Concerns

-Sierra Madre Northwest Biodiversity Area

- High erosion potential because of steep slopes.
- Sedimentation problems on Nuggett Creek and Placer Creek due to historic mining activity.

-Sierra Madre Southwest Biodiversity Area

- Moderate to high erosion potential in foothills areas.
- Poor water quality due to heavy metal pollution in Haggerty Creek.
- Elevated lead levels documented in the North Fork Little Snake River (results were inconclusive).

- Sediment spills from the Cheyenne Water Project affect several headwater streams in the North Fork Little Snake River drainage.
- Reduced flows in tributaries and mainstem of the North Fork Little Snake River caused by City of Cheyenne Water projects.

NORTH PLATTE RIVER DRAINAGE IN WYOMING

SIERRA MADRE MOUNTAINS (east of the Continental Divide) and MEDICINE BOW, SHERMAN, AND LARAMIE MOUNTAINS

Location

The North Platte River originates at the confluence of Grizzly and Little Grizzly Creeks in North Park, a 1,500-square-mile valley of north central Colorado. The river flows north into Wyoming through Northgate Canyon in the soutwestern Medicine Bow Mountains and continues northward through the Granite Mountains and several small basins in the central part of the state. The river flows around the northern end of the Laramie Mountains, southeast along the north side of the Laramie Mountains, then east into Nebraska to its confluence with the South Platte River near North Platte, Nebraska.

The east side of the Sierra Madre Mountains, all of the Laramie Mountains, and the western edge of the Sherman Mountains are part of the North Platte River drainage. The MBNF only comprises 17 percent of the drainage area of the North Platte River in Wyoming, but contributes 68 percent of the water into the system. National forest system lands of the MBNF are the major contributor of water to the drainage because the National Forest encompasses the headwaters of the major tributaries to the North Platte River. There are 68 sixth-level watersheds that collect water from the MBNF discharge into the North Platte River.

Topographic Diversity

The North Platte River drainage has considerable topographic diversity. The western, or headwater, portion of the drainage is dominated by high mountains and inter-montane valleys, with the Continental Divide as the western boundary. The eastern part of the North Platte Basin in Wyoming is in the High Plains region and features gently rolling plains and uplands sloping toward the east.

Topographic elevations in the drainage basin vary from about 5500 feet above sea level near the Wyoming border to 12,490 feet at the top of Atlantic Peak in the Wind River Mountains and 12,810 feet at the top of Howards Peak in Colorado. Between these extremes are mountain ranges at elevations of 8,000 to 12,000 feet, mountain valleys at elevations of 6,500 to 8,200, and high plains at elevations ranging from less than 5,000 to more than 6,000 feet above sea level.

Climate

Although the North Platte basin is in the latitudes of the prevailing westerlies with a dominance of maritime Pacific air, several mountain ranges alter storm patterns from the Pacific coast. The plains are semiarid as a result of their distance and isolation from moisture sources. The result is a varied precipitation pattern that ranges from 9-16 inches on the plains, 20 inches in the Laramie Range, and in excess of 40 inches in the Snowy Range and Sierra Madre Mountains in Wyoming and the Park and Medicine Bow Ranges in Colorado (See Climate Appendix 3).

Geology

The North Platte River basin has a long, complex history of sedimentation, erosion, and tectonic activity. Generally, the region is made up of broad, deeply eroded, granitic anticlines between which lie several synclinal basins, or parks, consisting of sedimentary deposits. The northernmost synclinal basin is North Park which is approximately 1,000 square miles in northern Colorado. North Park is part of a larger structural basin bisected by the Rabbit Ears Range, the Never Summer Range, the Medicine Bow Mountains and the Sierra Madre Mountains (the Park Range in Colorado). The latter two ranges and the Laramie Mountains extend into Wyoming, where they decrease in elevation and become buried by surrounding sedimentary deposits. This sedimentary-granitic rock contact serves as the approximate boundary between the Southern Rocky Mountains and the Wyoming Basin.

Water Use

The North Platte River is one of the most heavily used and controlled rivers in the United States. Its water is used for recreation and hydropower generation and is diverted for irrigation, municipal, and industrial uses. The river's average annual discharge is 1,687,600 acre-feet, 877,300 acre-feet of which are depleted due to irrigation, municipal, and industrial uses, as well as through reservoir evaporation (USGS 1983). The headwaters, where the MBNF is located, are not dammed.

Water Quality

The major sources of non-point pollution within the drainage are from non-irrigated and irrigated cropland, pastureland, and rangeland. Point source pollution within the drainage originates from feedlots and road, highway, and bridge construction. Pollutants include sediment/silt, organic enrichment, pathogens, pesticides, metals, ammonia, and nutrients. Flow and habitat alteration activities can also potentially degrade water quality.

Reservoirs and Lakes

Rob Roy Reservoir is located in the Douglas Creek watershed at an elevation of 9,400 feet. It is 800 surface acres with a maximum depth of 125 feet. The reservoir was constructed in 1964-1965 to augment the municipal water supply for the city of Cheyenne. It was enlarged in 1984-1985 for the Stage II expansion of the Cheyenne Water Development Project. Longnose suckers are the dominant fish in the reservoir. Yellowstone cutthroat trout, rainbow trout, splake, brook trout, and brown trout are also present (Oberholtzer 1989; Snigg 1989).

Hog Park Reservoir is 695 surface acres and has a capacity of 29,300 acre feet of water (Photo E-16). The height of the dam was increased to provide additional storage capacity for Stage II of the Cheyenne Water Development Project. As a result, water surface elevation also increased, and vegetated areas in the reservoir's upper reaches were flooded. Short term productivity in the reservoir has probably been enhanced as a result of the increase in nutrient availability from the flooded areas (Meyer personal communication).

Lake Owen is located in the Fox Creek drainage at an elevation of 8,955 feet. The lake is 120 surface acres with a maximum depth of 13 feet. Lake Owen is part of the municipal water supply for the City of Cheyenne and water flowing through the lake is controlled by the Cheyenne Board of Utilities. The lake contains brown trout, brook trout, rainbow trout, splake, and longnose suckers.

Watershed Concerns

SIERRA MADRE MOUNTAINS

-Encampment River Biodiversity Area

- High erosion potential in canyons (steep slopes).
- Altered channel structure resulting from historical tie drives.
- Unstable channels in the lower reaches of Damfino Creek and East Fork Encampment River.
- Unstable channels below Hog Park Reservoir due to disturbance and sediment spills and variable flows.

-Sierra Madre Southeast Biodiversity Area

- High soil erosion potential near eastern Forest boundary.

MEDICINE BOW MOUNTAINS

-Snowy Range North - West Biodiversity Area

- Altered stream channels due to historic tie drives.
- Mass wasting in many areas in the Cedar Creek subbasin.
- Widespread channel instability in Middle Cedar Creek.
- Siltation affecting trout habitat in the lower reaches of all streams.

-Snowy Range North - East Biodiversity Area
- A washout affecting Wagonhound Creek.
- Channel instability on low gradient sections of East Fork Medicine Bow River.
- Altered channel structure on Rock Creek and Turpin Creek due to historical tie drives.
- Severe channel alteration on Deep Creek below Sand Lake Dam from large releases for irrigation.

-Snowy Range North - Northeast Central Biodiversity Area
- No known major watershed problems.

-Snowy Range South - Southeast Biodiversity Area
- Poor habitat and riparian conditions in some streams.

-Snowy Range South - South central Biodiversity Area (Douglas Creek)
- Altered channel structure on most streams from historical tie drives.
- Point source pollution (heavy metals from mines) on Lower Douglas Creek.
- Damage to riparian areas from recreational use.
- High erosion potential in the Devil's Gate area.

-Snowy Range South - Wilderness Biodiversity Area
- No known major watershed problems.

LARAMIE MOUNTAINS
-Laramie Mountains North - Northwest Biodiversity Area
- Highly unstable, eroding banks on Deer Creek resulting from trampling and intensive grazing by livestock.
- Beavers few to absent in most areas.
- Willows damaged to absent in many areas due to grazing and wildlife use.

-Laramie Mountains North - North Central Biodiversity Area
- Localized channel instability.

-Laramie Mountains South - South Central Biodiversity Area
- Severe impacts to portions of the Horseshoe Creek due to water diversions for irrigation.
- Poor channel conditions in lower elevations near Forest boundary.
- Beavers are absent from many tributaries.
- Intensive livestock use throughout the area.

Laramie Mountains South - Southern Biodiversity Area
- Southwest Biodiversity Area

- Extensive siltation in pools.
- Alteration of some stream channels due to water storage and irrigation diversions.
- Intensive grazing impacts evident in some riparian areas.

SOUTH PLATTE RIVER DRAINAGE IN WYOMING

SHERMAN MOUNTAINS - eastern side

Location

The South Platte River drainage in southeastern Wyoming has four major sub-drainages which originate in the Sherman Mountains. Thse are Lodgepole Creek, Crow Creek, Lone Tree Creek, and Dale Creek. The entire drainage within the State of Wyoming is about 30 miles by 72 miles, comprising more than 1,380,000 acres. The Pole Mountain area of the Medicine Bow National Forest is situated in the headwaters of the drainage and represents approximately 4 percent of the total area.

Topographic Diversity

The drainage basin varies from flat farmland east of Cheyenne to rolling grasslands between Cheyenne and Pole Mountain. The Pole Mountain Unit of the Laramie Range District is a mosaic of timbered terrain interspersed with low grassy hills in the Sherman Mountains. Elevations range from a low of 5,042 feet near Pine Bluffs, Wyoming to 9,053 feet on Pole Mountain.

Climate

Climate within the watershed is affected by elevation changes and local topographic features. In the headwaters region, average annual precipitation is approximately 14 to 16 inches. Average annual precipitation in the lower part of the basin near Scotts Bluff is nine to 13 inches.

Geology

The headwaters region of the South Platte River is composed primarily of Sherman granite. Sedimentary rocks are comprised of claystone, sandstone, and conglomerate from Cheyenne south to the Colorado border and east the Nebraska border.

Water Use

Average annual discharge for the South Platte River in Wyoming is approximately 19,700 acre-feet. Irrigation is a major consumer of South Platte River water, diverting 4,300 acre-feet annually. Municipalities and industry consume 4,800 acre-feet per year. Reservoir evaporation losses account for 3,100 acre-feet annually (Wyoming Water Commission 1990). Other uses include recreational fishing in the Pole Mountain Unit of the Medicine Bow National Forest and water for wildlife.

Water Quality

Hydrologic and habitat modifications, such as flow alteration and the draining and filling of wetlands, are the most significant sources of nonpoint pollution in the South Platte River drainage. Point sources of pollution are primarily associated with the city of Cheyenne and highways and bridges. Major pollutants include pesticides, ammonia, chlorine, nutrients, sediment/silt, pathogens, and oil and grease.

Watershed Concerns

- Riparian areas on Crow Creek are affected by repairs to the city of Cheyenne water system.
- Water flow in Crow Creek is augmented from west-slope diversions from the Little Snake River.

TYPES OF AQUATIC ECOSYSTEMS

High Mountain Lakes

There are over 100 glacial lakes within the Snowy Range area of the MBNF (Photos E-2, E-4, E-108). These lakes are in the headwater regions of French Creek, Brush Creek, Medicine Bow River, and the Big Laramie River. All of the lakes within the Snowy Range are considered to be typical for high elevation environments. A complete description of the physical, biological, and chemical makeup of these lakes is provided by Snigg (1988). Additional information characterizing lakes in the Snowy Range is provided in Musselman (1992) and Guenther (1989). Because the physical and chemical nature of these lake is so similar, the following discussion applies to all high elevation lakes in the Snowy Range.

Lake Morphology

The lakes in the Snowy Range were formed during the last glacial episode, probably by ice scour and moraine deposition (Musselman, 1992). Most of the lakes are small (less than 40 surface acres) with maximum depths ranging from 70 feet in North Gap Lake to less than three feet in many of the smaller lakes. All of the lakes are over 9,500 feet elevation. Bathometric maps for each of the lakes are available (Snigg 1988). Geomorphic conditions for several lakes in the Snowy Range are described by Miller (1989).

Lake Hydrology and Thermal Properties

Lake hydrology is dominated by snow pack melt behavior. In the spring, the streamflow into these lakes has a diurnal pattern. These high elevation lakes are usually dimictic; i.e. they exhibit thermal stratification under the ice (Guenther 1989; Musselman 1992). During the ice-free summer months the lakes rarely exhibit strong thermal stratification. Thermoclines have been documented to affect the chemical and biological nature of some of the lakes in the Snowy Range (Musselman 1992; Guenther 1989). Guenther (1989) further found that the amount of inflow, snow and ice pack, depth of the water body, and macrophyte abundance controlled winter oxygen levels.

Chemical Properties

The lakes in the Snowy Range are typical, high elevation, oligotrophic lakes. Water chemistry data has been reported by Snigg (1988), Guenther (1989) and Musselman (1992). Water chemistry of West and East Glacier Lakes is strongly influenced by geologic, edaphic and hydrologic processes. This is believed to be true for all of the high elevation lakes within the Snowy Range. The lakes have low buffering capacity and are impacted by an acidic pulse during spring runoff. Water temperatures are typically below 60 degrees Fahrenheit and dissolved oxygen levels are greater than eight mg/l during the summer months. Dissolved oxygen (DO) levels during the winter months have been recorded as low as two mg/l. These low oxygen levels produced fish kills (Young personal communication). Turbidities in these lakes are low (< 1.0 mg/L), and pH ranges from 6.6 to 8.7 (Snigg 1989).

Moraine Ponds

Moraine ponds are common in the Snowy Range of the Medicine Bow Mountains (Photos E-6, E-8). These ponds can be divided into two broad types based on differences in elevation: high elevation ponds over 9,800 feet usually on ground moraines, and lower elevation ponds located on lateral moraines.

The high altitude ponds (over 9,500 feet) tend to be oligotrophic and slightly acidified (Blake 1945). Little vegetation develops in these acidic waters. Generally these ponds are at or above timberline and are surrounded by sedges, rushes, and small willow with scattered spruce and lodgepole pine. Because of the high altitude, water temperatures seldom exceed 65 degrees Fahrenheit during the summer months (Blake 1945). Ponds vary in depth between two and four feet, and banks drop rapidly to deep water.

Lower elevation ponds are generally more productive, have higher water temperatures, and tend to have larger amounts of emergent vegetation. Ponds can range in size from a few feet across to more than an acre. The pH of ponds around Long Lake were found to be slightly acidic, with smaller ponds more acidic than larger ones (Bartelt and Orde 1987). Water temperatures of 74 degrees Fahrenheit have been recorded during late summer. The amount of emergent vegetation is dependent upon the current stage of succession in the pond. Numerous sedge species occupy the littoral zones. In many area, particularly the headwaters of Brush Creek and the Medicine Bow River, dense stands of spruce-fir shade the smaller ponds.

Many of the lower elevation ponds have been affected by past logging activity (Photos E-8, E-87). When trees around a pond are removed, sun exposure is increased and water temperatures increase significantly (Bartelt and Orde 1987). Bartelt and Orde also found that the removal of adjacent trees increased evaporation levels. Increased sun exposure also had a detrimental effect on wood frog egg masses by greatly increasing mortality due to mold (Bartlet and Orde 1987). Other studies are currently under way to examine the effects of clearcutting on the biotic integrity of invertebrates in montane wetlands (Reyes, 1994).

Reservoirs

Several small irrigation reservoirs are located in the Snowy Range area of the Medicine Bow Mountains. These lakes are generally small in size (less than 100 acres). Several are stocked with fish by Wyoming Game and Fish Department but, because of severe water depletion or draw down in the summer and fall, they experience winterkill problems. Turpin Reservoir in the Snowy Range is one of the few small reservoirs in the Snowy Range which does not experience severe fall drawdown. Little information is available on the chemical and physical nature of these small reservoirs on the Forest. However, Snigg (1989) provides bathometric and basic water chemistry information for these reservoirs.

The two large reservoirs on the MBNF are Hog Park and Rob Roy (Photos E-15, E-16). Both of these reservoirs are part of the city of Cheyenne water storage and replacement system. During the late summer, water is released from the

reservoirs to meet downstream irrigation and municipal demands. The reservoirs are filled again in the spring. Both of these reservoirs are managed by Wyoming Game and Fish Department as recreational fisheries.

Streams

Rosgen (1985) developed a stream classification system based on morphological features for different hydrologic and geographic regions. Criteria used to delineate channel types were gradient, sinuosity, width to depth ratio, dominate substrate, entrenchment and confinement of the channel, landform features, and soil erodability and stability. Under this classification system, streams are divided into five basic types. The A channels have a high gradient (4% to 10%) and are well confined, B channels have a moderate gradient (2% to 4%) and are moderately confined, C channels have a low gradient (less than 2%) and are lightly confined, D channels are braided with no confinement, E channels are meandering streams, and G channels are glacial streams.

There are few A channels on the Medicine Bow National Forest (Photo E-65). Exceptions can be found in the headwaters of South French Creek and Big Creek (tributaries to the North Platte River), some headwater streams in the North Fork Little Snake River (part of the Little Snake drainage) and portions of LaBonte Canyon (Photo E65). These high-gradient channels are generally composed of bedrock or large boulders and have little capacity sediment storage. Water velocities in these channel are high. In Rabbit Creek (a tributary in the North Fork Little Snake River drainage) high velocities create barriers to the upstream movement of fish.

Most streams on the MBNF are classified as B channels (Photos E-27, E-28, E-29). Kozel (1987) estimated that approximately 80 percent of the miles of perennial stream on the Forest fall into a B stream classification. The B channels tend to be located at mid-elevation between the headwaters and the foothills regions. Near the subalpine zone riparian vegetation along B channels is composed of spruce and fir. In montane areas lodgepole pine is dominant. Because trees are a major vegetative component within these riparian areas, they influence B channels, both in terms of shade and allochthonous energy production. Large wood and boulders are key components in the formation of stream habitat such as pools and riffles (Kozel 1987; Young 1994). Kozel further found B channels to be primarily fast water habitat (riffle, rapid, and cascade) with banks composed primarily of rock.

Less than 20 percent of the streams on the MBNF are classified as C or E channel types (Photos E-25, E-26). The C channels tend to be located in high elevation areas near headwaters or in the foothills. A wide range of habitat features and drainage sizes are in C channels in these very different locations

(Kozel, 1987). At mid- to high-elevation areas riparian vegetation along C channels is primarily willow, alder, sedges, rushes, and various grasses. In the foothills, a mixture of sagebrush, willows, and grasses is dominant.

Kozel (1987) found unaltered C channels to be significantly deeper and narrower with more overhanging bank and pools than B channels (Kozel 1987; Wesche 1987). Low gradient channels are also more prone to sediment deposition because of reduced stream energy and more susceptible to channel instability resulting from greater flow fluctuation and poor channel armoring (Kozel 1987). Wesche (1987) found C channels on Douglas Creek to be more heavily impacted by historic activities (e.g. tie drives) than B channels. C channels are more susceptible to destabiizing damage because they have poorly armored substrates and a reduced capacity to transport sediment.

AQUATIC COMMUNITIES

High Mountain Lakes

Phytoplankton

The vast majority of phytoplankton sampling has been done in conjunction with the Glacier Lake Ecosystem Experiments Site-GLEES (Musselman 1994). The lakes sampled in the GLEES project are high-elevation and are geologically old (greater than 10,000 years). The types of algae found in these lakes vary and include diatoms, green algae, golden-brown algae, cryptophytes, blue-green algae, euglenoids, and dinoflagellates. Phytoplankton abundance varies seasonally, with green and blue-green algae peaking during the late summer and early fall as water temperatures increase. Phytoplankton species collected from these high-elevation lakes are typical of those found in cold, oligotrophic lakes. A complete species list can be obtained from Musselman (1994). Other information concerning phytoplankton populations on the Medicine Bow National Forest is found in Giles (1933) and Simon (1937).

Zooplankton

As with phytoplankton sampling, the vast majority of zooplankton sampling has been done in conjunction with the GLEES project (Musselman, 1994). Zooplankton populations are generally sparse in these high mountain lakes. The types of zooplankton collected include Rotaria (*Kellicottia longispina, Polyarthra dolichopter, Keratella* sp. and *Lecane* sp.) and Entomostraca (*Diacyclops thomasi, Ceriodaphnia* sp. and *Daphnia ambigua*).

Macroinvertebrates

Macroinvertebrate studies on lakes in the Snowy Range area of the Medicine Bow National Forest have been conducted by Giles (1933), Simon (1938), Blake (1945), Hepworth (1959), Royer (1960) and Payne (1983). Most of these studies were conducted as part of fisheries investigations on trout diets. Major groups collected include Oligochaeta (aquatic worms), Arthropods including Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (Caddisflies), Diptera (true flies), and Pelecypoda (clams).

Fish

Historically there were no native game fish in the Snowy Range lakes (Baxter and Simon 1970). Species indigenous fish to the high mountain lakes were white sucker and longnose dace (Baxter pers. comm.). Brook trout were first introduced into the lakes in the 1920s and 1930s (Table 4.3, Chapter 4). They reproduce rapidly once stocked because they are well adapted to spawning in the small streams in the area (Snigg 1989).

Of the 97 high mountain lakes in the Snowy Range, 55 presently contain naturally reproducing populations of brook trout (Snigg 1989). The 55 lakes also contain other species such as golden trout, splake, rainbow, cutthroat, and brown trout. Numerous other lakes have no fish or are prone to winterkill and require periodic stocking to maintain a viable fishery.

Moraine Pond Communities

No recent data on aquatic communities are available for these moraine ponds. Blake (1945) identified fairy shrimp, copepods, damselfly, water striders, aquatic beetles, caddice worms, and mosquito larvae in the ponds he examined. Wood frogs are also likely to inhabit ponds at this elevation. Blake also reported seeing numerous western boreal toads in the areas surveyed.

Stream Communities

Macroinvertebrates

Macroinvertebrate sampling on the Medicine Bow National Forest has been conducted by a number of investigators (See Appendix 1 - Bibliography of Scientific Studies). The vast majority of Macroinvertebrate sampling has been conducted by the Wyoming Game and Fish Department as part of their routine fisheries surveys. Data from these efforts is available from the Wyoming Game and Fish Department's Lake and Stream Database. These general surveys include

basic water chemistry data and macroinvertebrate information down to the Order level only.

A list of macroinvertebrates collected from streams on the Medicine Bow National Forest is in Table 7.3. These taxa are characteristic of streams and lakes that have a narrow range of environmental conditions including low water temperatures, high water quality, high levels of dissolved oxygen, and good aquatic habitat diversity (Hynes 1970). The only exceptions are representatives of the Order Diptera (true flies). They are generally tolerant of a wide range of environmental conditions, including high temperatures, low dissolved oxygen levels, and poor habitat conditions.

Blake (1945) described small and large streams over 9,700 feet in the Medicine Bow Mountains. The water in the small streams sampled was slightly alkaline. Summer water temperatures were usually less than 50 degrees Fahrenheit. The dominant macroinvertebrate, planaria (*Polycelis coronata*), is abundant under rocks in many of the streams. Common mayflies include the heptagenid and baetid mayflies. Stoneflies are also abundant. Caddis flies were largely represented by net builders.

The effects of spring runoff on macroinvertebrate populations in the Snowy Range was examined by Good (1974). Macroinvertebrates were found to adjust their life cycle as an adaptation to the high spring flow in three ways: 1) Diptera pupate prior to or after peak flows, 2) insects tended to breed during the peak flows, and 3) egg hatches tended to occur after the peak flow since newly hatched individuals are more vulnerable to high flow than are eggs.

Table 7.3. Macroinvertebrate species list for the MBNF.

LITTLE SNAKE RIVER DRAINAGE

I. Phylum Arthropoda

A. Class Insecta

1. Order Ephemeroptera (mayflies)
    1. Ameletus sp.
    2. Baetis sp.
    3. Cinygmula sp.
    4. Epeorus sp.
    5. Ephemerella coloradensis
    6. E. doddsi
    7. E. grandis
    8. E. hecuba
    9. E. inermis
    10. E. tibialis
    11. Heptagenia sp.
    12. Paraleptophlebia sp.
    13. Rhithrogena sp.
    14. Tricorythodes minutus

2. Order Plecoptera (stoneflies)
    1. Alloperla sp.
    2. Amphinemura sp.
    3. Cultus sp.
    4. Hesperoperla pacifica
    5. Isoperla sp.
    6. Malenka sp.
    7. Megarcys sp.
    8. Skwala parallela
    9. Taenionema sp.
    10. Zapada sp.

3. Order Trichoptera (caddisflies)
    1. Arcotopsyche californica
    2. A. grandis
    3. Brachycentrus sp.
    4. Docosmoecus sp.
    5. Glossosoma sp.
    6. Hydropsyche sp.
    7. Limnephilidae sp.
    8. Micrasema sp.
    9. Neothremme sp.
    10. Polycentropus sp.
    11. Psychoglypha sp.
    12. Rhyacophila sp.

TABLE 7.3. Continued

LITTLE SNAKE RIVER DRAINAGE (contd)

4. Order Coleoptera (beetles)
    1. Heterlimnius corpulentus
5. Order Diptera (flies, mosquitoes, blackflies)
    1. Antocha monticola
    2. Blepharicera sp.
    3. Dicranota sp.
    4. Hexatoma sp.
    5. Pericoma sp.
    6. Simulium sp.

B. Class Turbellaria

1. Order Tricladida (flatworms)
    1. Planaria sp.

NORTH PLATTE RIVER DRAINAGE

I. Phylum Arthropoda

A. Class Insecta

1. Order Trichoptera (caddisflies)
    1. Agapetus sp.
    2. Apatania zonella
    3. Arcotopsyche sp
    4. Brachycentrus sp.
    5. Dicomoecus sp.
    6. Ecclisomyia sp.
    7. Hesperophylax occidentalis
    8. Hydropsyche sp.
    9. Hydroptila sp.
    10. Limnephilus coloradensis
    11. L. picturatus
    12. Platycentropus sp.
    13. Pycnopsych sp.
    14. Rhycophila sp.

Table 7.3. Continued

NORTH PLATTE RIVER DRAINAGE (contd)

2. Order Ephemeroptera (mayflies)
    1. Ameletus sp.
    2. Baetis bicaudutus
    3. B. intermedius
    4. B. levitans
    5. B. tricaudata
    6. Centroptilum sp.
    7. Cinygmula sp.
    8. Ecdyurus ramaleyi
    9. Epeorus sp.
    10. Ephemerella coloradensis

I. Phylum Arthropoda

A. Class Insecta
Order Ephemeroptera (contd)

    11. E. doddsi
    12. E. grandis
    13. E. inermis
    14. E. infrequens
    15. E. margarita
    16. E. tibialis
    17. Heptagenia sp.
    18. Heterocloeon sp.
    19. Paraleptophlebia sp.
    20. Rhithrogena brunnea
    21. R. doddsi
    22. R. minus
    23. R. robusta
    24. Tricorythodes sp.

3. Order Plecoptera (stoneflies)
    1. Acroneuria pacifica
    2. Alloperla autumna
    3. A. borealis
    4. A. lambda
    5. A. lineosa
    6. Arcynopteryx parallela
    7. A. signata
    8. Brachyptera nigripennis
    9. Capnia coloradensis
    10. C. confusa
    11. Clioperla ebria

Table 7.3. Concluded

NORTH PLATTE RIVER DRAINAGE (contd)

12. Eucapnopsis brevicauda
13. Isogenus modestus
14. Isoperla aestivales
15. I. fulva
16. Nemoura arctica
17. N. cinctipes
18. N. oregonensis
19. Paraleuctra sp.
20. Paraperla frontalis
21. Pteronarcella badia
22. Podmosta delicatula
23. Skwala parallela

I. Phylum Arthropoda

4. Order Coleoptera (beetles)
   1. Bidessus sp.
   2. Cleptelmis sp.
   3. Heterlimnius sp.
   4. Hydrovatus sp.
   5. Zaitzevia sp.

5. Order Diptera (flies, mosquitoes, blackflies)
   1. Anatopynia dyari
   2. Antocha monticola
   3. Atherix variegata
   4. Calopsectra sp.
   5. Cryptochironumus sp.
   6. Dicranota sp.
   7. Hexatoma sp.
   8. Limnophora sp.
   9. Polypedilum sp.
   10. Prosimulium sp.
   11. Tendipes attenuatus

II. Phylum Mollusca (clams, snails)

1. Pisidium sp.

III. Phylum Annelida (true worms)

1. Limnodrilus sp.
2. Tubifex sp.

Two studies relating substrate types, flow regimes and chemical water quality to macroinvertebrate communities have been conducted on streams at elevations less than 9,800 feet on the Forest (Kimble and Wesche 1975; Debrey and Lockwood 1988). Both of these studies were conducted in the Sierra Madre Mountains on the Medicine Bow National Forest. A summary of the studies by substrate types follows:

-Stream Substrates

1. Silt

Diptera, primarily Tendipedidae, were the dominant macroinvertebrate group (by number) in silt substrates (Kimble and Wesche 1975). As a family, this group prefers muddy silt for the construction of their cases and tubes. Both caddisflies and stoneflies are absent from this substrate type. Mayflies and beetles comprise a minor proportion of the benthic fauna present. In general, this substrate type supports low numbers of benthic fauna and few species.

2. Sand and Gravel

Typically, macroinvertebrate species diversity is greater in sand and small gravel substrates than in silt substrates. Mayflies, flies, and beetles tend to dominate in these substrate types (Kimble and Wesche 1975). However, Debrey and Lockwood (1988) found stoneflies, true flies, and one representative of the caddisfly order utilizing sand substrates at least on a seasonal basis. Representatives of the Order Diptera (true flies) were the only macroinvertebrates to utilize these substrates year round. The other families shifted use from sand substrates to gravel and rubble substrates during late summer and early fall. No data has been collected on macroinvertebrate substrate preferences during the winter months.

3. Large Gravel and Rubble

Substrates dominated by large gravel and rubble support the largest numbers of macroinvertebrate species (Kimball and Wesche 1975; Debrey and Lockwood 1988). These substrates were dominated by caddisflies, mayflies, and beetles, with true flies and stoneflies being of minor importance. These habitats tended to have more heterogeneous substrates and greater water velocities. This increased heterogeneity has been hypothesized to be one of the major factors leading to a higher diversity of aquatic macroinvertebrates (Minshall et al. 1983).

4. Boulder/bedrock

Sampling of macroinvertebrate from boulder habitats on the MBNF has only been conducted by Debrey (1988). The only family shown to have a preference for boulder substrates was Hydropsychidae in the Order Tricoptera (caddisflies). This is probably due to Hydropsychidae utilizing bedrock areas as a point of attachment for food collection. Mayflies, caddisflies, stoneflies, true flies, and beetles utilize boulder substrates more than sand and silt substrates, but less than gravel and rubble.

FISH BIOLOGICAL DIVERSITY

Since the 1860s the introduction of many exotic fish species in areas occupied by native fish and the introduction of both native and exotic species into fishless lakes has significantly changed the composition and diversity of fish species. The building of two large reservoirs within the Forest followed by sport-fish stocking introduced a new dimension of biological diversity into the area now administered by the Medicine Bow National Forest.

Eleven fish species are considered indigenous to the Little Snake River drainage of Wyoming (Table 7.4). Of these, nine are known to have occurred in the headwaters of the drainage within the National Forest boundary. Five fish species have been introduced into the drainage, of which four are known to occur on the MBNF.

Thirty-five fish species are considered native to the North Platte River drainage; 25 have documented occurrences in Wyoming (Table 7.5). Prior to 1874, only four species (white sucker, longnose dace, longnose sucker, and creek chub) were known to occur on the Medicine Bow National Forest (D. Miller pers. comm.; G. Baxter, pers. comm.). Nineteen fish species have been introduced to the North Platte drainage; eight are presently known to occur on the National Forest (Table 7.5).

Sixteen fish species are considered native to the South Platte drainage of Wyoming (Table 7.6). Of these, only greenback cutthroat trout and longnose sucker are thought to have occurred on the Pole Mountain portion of the Medicine Bow National Forest (Baxter pers. comm.). Seven fish species have been introduced in the South Platte drainage of Wyoming. Three of these species are known to occur on the National Forest.

Table 7.4 **Indigenous fish species of the MBNF**
+ Taxa (boldface) known to occur on the MBNF.

Drainage	Species
LITTLE SNAKE RIVER	**Colorado River cutthroat trout +**
	Mountain whitefish +
	Creek chub +
	Roundtail chub +
	Colorado River squawfish *
	Speckled dace +
	White sucker +
	Flannelmouth sucker +
	Mountain sucker +
	Mottled sculpin +
	Bluehead sucker
NORTH PLATTE RIVER	**White sucker +**
	Longnose sucker +
	Creek chub +
	Longnose dace +
	Shovelnose sturgeon
	Goldeye
	Quillback
	River carpsucker
	Northern redhorse
	Hornyhead chub
	Flathead chub
	Suckermouth minnow
	Common shiner
	Red shiner
	Bigmouth shiner
	Sand shiner
	Brassy minnow
	Plains minnow
	Fathead minnow
	Stone roller
	Black bullhead
	Stonecat
	Plains topminnow
	Plains killifish
	Sauger (currently not present)
	Iowa darter
	Johnny darter

Table 7.4. Continued

Drainage	Species
SOUTH PLATTE RIVER	**White sucker +**
	Creek chub +
	Longnose dace +
	Common shiner
	Sand shiner
	Bigmouth shiner
	Suckermouth minnow
	Brassy minnow
	Fathead minnow
	Stoneroller
	Plains topminnow
	Plains killifish
	Iowa darter
	Johnny darter
	Orangethroat darter
	Greenback cutthroat trout (Historically found in Dale Creek)

+ Taxa (boldface) known to occur on the MBNF.

Table 7.5. **Introduced fish species in the North Platte, South Platte and Colorado River drainages of Wyoming.**

Drainage	Species
LITTLE SNAKE RIVER	**Brook trout +**
	Brown trout +
	Rainbow trout +
	Yellowstone cutthroat trout
	Carp
NORTH PLATTE RIVER	**Yellowstone cutthroat trout +**
	Colorado River cutthroat trout +
	Rainbow trout +
	Golden trout +
	Brown trout +
	Brook trout +
	Artic Grayling *
	Smallmouth bass *
	Green sunfish +
	Splake +
	Threespine stickleback +
	Northern pike
	Kokanee
	Carp
	Golden shiner
	Largemouth bass
	Pumpkinseed
	Walleye
	Yellow perch
SOUTH PLATTE RIVER	**Brook trout +**
	Brown trout +
	Rainbow trout +
	Colorado River cutthroat trout
	Carp
	Goldfish
	Pumpkinseed
	Black crappie

+ Taxa (boldface) known to occur on the MBNF Forest.
* Historical Occurrence

RIPARIAN AREA DELINEATION

In 1992-93, riparian areas on the Medicine Bow National Forest were delineated using aerial photo coverage. Criteria to define riparian areas included topographic and geomorphic characteristics as well as vegetation. When the width of the riparian area exceeded 160 feet, polygons were delineated, and the vegetation characterized. When the width of the riparian area was 160 feet or less, the area was shown as a line. Other riparian areas were indicated by points (for example, small kettleholes).

To estimate riparian acreages line segments representing riparian areas were multiplied by an average width based on sample measurements from topographic maps. Line widths were 63 feet for the Laramie Mountains, 72 feet for the Sierra Madre Mountains, and 94 feet for the Snowy Range and the Sherman Mountains. Riparian areas represented by points were assigned a value of one acre, the median size of small kettleholes and beaver ponds.

For riparian mapping, vegetation in the Resource Inventory System (RIS) database was reclassified into riparian groups within the following categories:

1. Riparian coniferous forest
2. Riparian deciduous forest
3. Riparian shrubland
4. Riparian grassland/forbland
5. Riparian non-vegetated
6. Miscellaneous wetlands (small wetlands)
7. Water (reservoirs)

Vegetation from RIS polygons was used to assign a vegetation type to the riparian areas. The estimated acreages, by Biodiversity Area and category, are in Table 7.6.

Riparian areas are shown in Figure 7.2. Riparian areas associated with crenulated drainages are not included in the map or table. The Riparian Area Maps show relative distributions of conifers, willow, aspen, and grassland/forbland (meadow) among the Biodiversity Areas. Because RIS vegetation data is only available for areas within the Forest boundary, the map shows only those riparian areas located on the Medicine Bow National Forest. Many valley riparian areas are outside the Forest Boundary in the Laramie Mountains. The Coarse Filter Analysis (Dean et al. in progress), a vegetation classification system using Landsat imagery, provides information on private and state lands.

Table 7.6. **Net NFS acres and per cent of riparian area in each Biodiversity Area. (Net NFS Acres in each BDA from GIS)**

	Acres	% of area
SIERRA MADRE MOUNTAINS	18982	5.6%
Sierra Madre Northwest	4245	4.1%
Sierra Madre Southwest	5756	5.0%
Sierra Madre Encampment River	6316	8.7%
Sierra Madre Southeast	2665	5.9%
MEDICINE BOW MOUNTAINS	37986	7.4%
Snowy Range North - West	8779	6.6%
Snowy Range North - East	7516	7.7%
Snowy Range North - E. Central	4746	7.0%
Snowy Range South - Wilderness	3142	5.5%
Snowy Range South - Central	9344	10.0%
Snowy Range South - Southeast	4409	7.0%
SHERMAN MOUNTAINS	4577	8.3
LARAMIE MOUNTAINS	7449	4.2%
Laramie Mts. North - Northwest	2079	3.9%
Laramie Mts. North - North Central	1029	3.7%
Laramie Mts. South - South Central	1277	2.6%
Laramie Mts. South - Southwest	2650	7.3%
Laramie Mts. South - Southern	414	3.2%
Total riparian area for MBNF	68944	6.4%

RIPARIAN AREA VEGETATION

Riparian areas bordering streams, springs, ponds, lakes, and reservoirs add diversity of both plants and animals to landscapes. There is also diversity within riparian areas as a result of varying topography, elevation, stream characteristics, water depth, beaver activity, and disturbance. Riparian and aquatic areas together contain the most biological diversity, acre for acre, of any ecosystems on the landscape. The importance of riparian areas for wildlife and birds is discussed elsewhere in this report.

There have been three efforts to classify riparian ecosystems on the Medicine Bow National Forest. Portions of Battle Creek, Big Sandstone Creek, North Soldier Creek, Beaver Dam Park and Big Creek were studied by Jones (1992). Von Ahlefeldt (1992) studied riparian areas in the Laramie Mountains in 1991 and 1992. Mastel (1995) has been studying high-elevation riparian areas on the Brush Creek District.

Information from these studies has been included in Appendix 6, Plant community diversity of the Medicine Bow National Forest. The classification is based on a combination of formal field studies and known occurrences of species. All of the plant communities studied on the Medicine Bow National Forest have been described previously in the literature. Additional information on riparian areas appears earlier in this chapter in Appendix 13, Watershed Descriptions.

Riparian vegetation on the Medicine Bow National Forest can be divided into six physiognomic categories, plus water (Table 7.7). Some common community types for each Category are presented in Table 7.9. The net NFS acres and percent of net NFS land in riparian areas for each Biodiversity Area is in Table 7.8. The acres of riparian cover types by Biodiversity Unit are in Table 7.9.

Above and near timberline in the Medicine Bow Mountains are extensive areas of wet forblands and meadows, mainly north of Medicine Bow Peak. Tufted hairgrass meadows are the most common communities. Forblands of elephantshead and elkslip marshmarigold are interspersed with wet sedge meadows. Extensive areas of short willows occur in glacial till and at the heads of streams above timberline. Kettleholes north of Medicine Bow Peak usually have sedge and rush communities around their borders where soil is available under shallow water. Water lilies are common in larger kettleholes at about 9,600 feet.

Upper elevation, high-gradient streams in the Sierra Madre Mountains, the northern Medicine Bow Mountains, and northern Laramie Mountains are generally within spruce-fir forests. In the southern Medicine Bow Mountains, there are extensive willow communities and beaver ponds along stream channels. In some areas, a high water table from beaver impoundments extends across the valley bottom resulting in the growth of extensive willow communities. Willow communities are more restricted in the Sierra Madre Mountains, Sherman Hills, and Laramie Mountains, where they grow in narrow bands along stream channels which may be severely confined in valleys or canyon bottoms.

Table 7.7. Categories of riparian vegetation on the MBNF.

Category	Number of community types
Riparian coniferous forest	35
Riparian deciduous forest	27
Riparian shrublands - non-willow	15
Riparian shrublands - willow	36
Riparian forblands	18
Riparian grasslands (including sedge and rush communities)	37

Low-gradient streams occur in the southwestern Sierra Madre Mountains, northern Medicine Bow Mountains, and in portions of the Douglas Creek drainage. In the Sherman Mountains most streams are low gradient. In the Laramie Mountains, most low-gradient stream segments are located on private or state lands.

Canyons provide a special kind of riparian environment. Conditions range from protected microsites to areas which are strongly impacted by flooding. Large, steep-sided canyons include the Platte River Canyon in the southwestern Medicine Bow Mountains, the Encampment River Canyon in the Sierra Madre Mountains, and the Laramie River Canyon and LaBonte Canyon in the Laramie Mountains. Long narrow, river valleys, originating in alpine or subalpine terrain, provide some of the major streamside riparian areas. Steep, short valleys around the edges of the mountain ranges, and in the vicinity of Laramie Peak provide another kind of riparian environment, often dominated by shrubs or aspen.

DISTURBANCE IN RIPARIAN AREAS

Stream environments are greatly influenced by flash floods. Flooding may be caused by rapid melting of the snowpack in the spring or by summer convectional storms. In the southwestern Sierra Madre Mountains sudden springtime temperature increases may cause the heavy snowpack to melt rapidly resulting in flash flooding. In the Laramie Mountains intense precipitation events over areas of impervious rock produce heavy runoff and flooding. These discontinuous events create disturbance patterns which influence riparian vegetation composition and structure in characteristic ways for each drainage.

Table 7.8. **Examples of common riparian community types. SM = Sierra Madre; SR = Snowy Range; SH = Sherman Mts. LM = Laramie Mts.**

Community	Mountain Range			
	SM	SR	SH	LM
Riparian Coniferous Forest				
spruce-fir/broadleaf arnica	x			
spruce-fir/arrowleaf groundsel	x	x		
spruce-fir/bluejoint reedgrass	x	x		
spruce-fir/moss	x	x		
subalpine fir/sweetscented bedstraw			x	x
Engelmann spruce/elkslip marshmarigold	x	x		
Engelmann spruce/softleaved sedge	x	x		
Engelmann spruce/field horsetail	x	x		x
Ponderosa pine/red-osier dogwood				x
Ponderosa pine/Kentucky bluegrass				x
Riparian Deciduous forest				
Narrowleaf cottonwood/water birch	x	x		x
Narrowleaf cottonwood/red-osier dogwood	x	x		x
Narrowleaf cottonwood/Kentucky bluegrassx	x		x	
balsam poplar/red-osier dogwood				x
aspen/Oregon grape	x	x	x	x
aspen/Wood's rose		x	x	x
aspen/Cow parsnip				x
aspen/Porter's ligusticum	x	x	x	x
aspen/Fendler meadowrue	x	x	x	x
aspen/Kentucky bluegrass	x	x	x	x
Riparian shrubland non-willow				
mountain maple/red-osier dogwood				x
thinleaf alder/water birch/water sedge	x	x		x
big sagebrush/Basin wildrye	x			
chokecherry/western snowberry		x	x	x
shrubby cinquefoil/tufted hairgrass	x	x		x
shrubby cinquefoil/Kentucky bluegrass	x	x	x	x
Riparian shrubland - willow				
Drummond willow/bluejoint reedgrass	x	x	x	x
Geyer willow/beaked sedge	x	x	x	x
Geyer willow/tufted hairgrass	x	x	x	x
planeleaf willow/elkslip marshmarigold	x	x		
planeleaf willow/tufted hairgrass	x	x	x	x
wolf willow/water sedge	x	x		
Riparian forbland				
elkslip marshmarigold/rose crown	x	x		
Canada thistle	x	x		x
mountain bluebells/tufted hairgrass	x	x		x
common cattail	x			x
Riparian grassland				
rock sedge/whiproot clover	x	x		
ticklegrass	x	x	x	x
Kentucky bluegrass	x	x	x	x
bluejoint reedgrass	x	x		x
mannagrass				x
water sedge/beaked sedge	x	x	x	x

TABLE 7.9 Cover types in riparian areas (Net NFS acres in each Biodiversity Unit and Biodiversity Area). See Fig. 7.2.

SIERRA MADRE		12	13	14	15	16	17	18	
SM-NW	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	Totals
Savery Creek	1	47	238	397	0	0	0	0	682
Dirtyman Creek	2	64	140	48	0	0	1	2	255
Big Sandstone Creek	3	201	342	557	14	6	0	6	1126
Jack Creek	13	33	227	525	0	0	3	14	802
North Spring Creek	14	23	343	364	0	0	3	35	768
South Spring Creek	15	7	193	36	1	0	1	2	240
Cow Creek	16	17	180	141	2	0	5	27	372
	Sum	392	1663	2068	17	6	13	86	4245

		12	13	14	15	16	17	18	
SM-SW	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	Totals
Little Sandstone Creek	4	244	51	470	15	0	5	0	785
Big Gulch	5	69	2	98	14	0	1	2	186
E. Sweetwater Gulch	6	0	0	51	1	0	0	0	52
Lower Battle Creek	7	172	12	392	26	8	1	0	611
Cottonwood Creek	8	57	10	355	7	0	0	0	429
Roaring Fk LSR	9	144	128	228	51	0	1	0	552
N. Fk LSR	10	307	629	862	145	6	6	23	1978
Upper Battle Creek	11	160	225	378	15	4	2	2	786
W. Fk. Battle Cr	12	59	116	158	44	0	0	0	377
	Sum	1212	1173	2992	318	18	16	27	5756

		12	13	14	15	16	17	18	Totals
SM-Enc. River	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	
N. Fk Encampment River	17	41	286	522	150	1	4	67	1071
S. Fk. Miner Creek	18	56	429	218	70	0	0	8	781
Hog Park Creek	19	46	374	495	91	2	0	586	1594
Encampment River Canyo	20	84	520	204	109	0	0	0	917
Billie Creek	21	51	186	317	0	0	1	0	555
E. Fk Encampment River	22	0	803	445	150	0	0	0	1398
	Sum	278	2598	2201	570	3	5	661	6316

		12	13	14	15	16	17	18	Totals
SM-SE	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	
Beaver Creek	23	95	318	404	0	0	0	0	817
Middle Fk Big Creek	24	80	574	532	23	0	0	0	1209
Bear Creek	25	61	123	30	0	4	0	0	218
S. Fk Big Creek	26	37	163	212	9	0	0	0	421
	Sum	273	1178	1178	32	4	0	0	2665

SIERRA MADRE TOTALS		2155	6612	8439	937	31	34	774	18982

TABLE 7.8. Net NFS Acres and per cent of riparian area in each Biodiversity Area. (Net NFS Acres in each BDA from GIS)

	Acres	% of area
SIERRA MADRE MOUNTAINS	18982	5.6%
Sierra Madre Northwest	4245	4.1%
Sierra Madre Southwest	5756.	5.0%
Sierra Madre Encampment River	6316	8.7%
Sierra Madre Southeast	2665	5.9%
MEDICINE BOW MOUNTAINS	37986	7.4%
Snowy Range North - West	8779	6.6%
Snowy Range North - East	7516	7.7%
Snowy Range North - E. Central	4746	7.0%
Snowy Range South - Wilderness	3142	5.5%
Snowy Range South - Central	9344	10.0%
Snowy Range South - Southeast	4409	7.0%
SHERMAN MOUNTAINS	4577	8.3
LARAMIE MOUNTAINS	7449	4.2%
Laramie Mts. North - Northwest	2079	3.9%
Laramie Mts. North - North Central	1029	3.7%
Laramie Mts. South - South Central	1277	2.6%
Laramie Mts. South - Southwest	2650	7.3%
Laramie Mts. South - Southern	414	3.2%
Total riparian area for MBNF	68944	6.4%

TABLE 7.9 Cover types in riparian areas (Net NFS acres in each Biodiversity Unit and Biodiversity Area). See Fig. 7.2. (cont)

SNOWY RANGE NORTH

SRN-West	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
S. Fk. Lake Creek	27	17	185	20	0	0	0	0	222
N. Cedar Creek	28	68	156	25	0	0	0	0	249
Rankin Creek	29	45	189	38	0	0	2	0	274
Pass Creek	30	128	832	227	0	14	14	4	1219
S. Cedar Creek	31	62	136	80	15	1	0	0	294
Lower N. Brush Creek	32	31	238	380	9	0	2	0	660
Upper N. Brush Creek	33	0	727	854	70	8	61	41	1761
S. Brush Creek	34	0	309	579	132	1	19	130	1170
Lower Brush Creek	35	30	111	381	4	0	0	0	526
N. Cottonwood Creek	36	19	147	94	21	0	1	0	282
Middle French Creek	37	31	296	310	166	0	7	21	831
Upper S. French Creek	38	3	327	264	42	1	10	109	756
Lower S. French Creek	39	47	171	305	12	0	0	0	535
	Sum	481	3824	3557	471	25	116	305	8779

SRN-Northeast	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Fourmile Creek	60	30	218	22	2	0	3	29	304
North Rock Creek	61	7	548	244	43	0	7	144	993
South Rock Creek	62	0	567	795	98	0	88	25	1573
W. Medicine Bow R	63	0	681	154	13	0	28	157	1033
Upper Medicine Bow River	64	0	65	311	124	1	48	335	884
Lower Medicine Bow River	65	22	1122	416	20	1	58	172	1811
East Medicine Bow River	66	16	331	174	2	3	10	5	541
Wagonhound Creek	67	0	154	213	6	0	4	0	377
	Sum	75	3686	2329	308	5	246	867	7516

SRN- East Central	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
South Fork	56	155	318	355	0	0	0	0	828
Middle Fork	57	2	370	1095	35	0	0	0	1502
North Fork	58	53	801	733	124	3	65	421	2200
Mill Creek	59	32	132	22	12	0	9	9	216
	Sum	242	1621	2205	171	3	74	430	4746

SNOWY RANGE NORTH TOTAL	798	9131	8091	950	33	436	1602	21041

TABLE 7.9 Cover types in riparian areas (Net NFS acres in each Biodiversity Unit and Biodiversity Area). See Fig. 7.2. (cont)

SNOWY RANGE SOUTH

SRS-Wilderness	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Mullen Creek	40	47	630	381	38	0	0	0	1096
Cottonwood Creek	41	9	262	263	39	0	0	0	573
Platte River	42	204	526	682	53	8	0	0	1473
	Sum	260	1418	1326	130	8	0	0	3142

SRS-Central	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Pelton Creek	43	156	348	1627	144	0	0	2	2277
Lower Douglas Creek	44	95	404	732	54	0	0	3	1288
Mowberg Creek	45	10	97	857	16	0	0	0	980
Lake Creek	46	0	120	911	84	0	0	0	1115
Muddly Creek	47	0	85	654	13	0	0	0	752
Middle Douglas Creek	48	0	202	631	26	0	1	4	864
Devils Gate Creek	49	17	135	342	59	0	0	2	555
Upper Douglas Creek	50	0	44	1164	16	0	0	289	1513
	Sum	278	1435	6918	412	0	1	300	9344

SRS-Southeast	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Boswell Creek	51	45	300	501	0	0	0	3	849
Bear Creek	52	209	345	362	5	0	0	61	982
Lake Owen Creek	53	152	477	1097	70	0	0	122	1918
Johns Creek	54	27	146	115	115	1	0	0	404
Buckeye Creek	55	37	281	105	19	0	0	0	442
	Sum	470	1549	2180	209	1	0	0	4409

SNOWY RANGE SOUTH T	Sum	1008	4402	10424	751	9	1	300	16895
SNOWY RANGE TOTAL	Sum	1806	13533	18515	1701	42	437	1902	37936
LOWER BOW TOTAL	Sum	3961	20145	26954	2638	73	471	2676	56918

TABLE 7.9 Cover types in riparian areas (Net NFS acres in each Biodiversity Unit and Biodiversity Area). See Fig. 7.2. (cont)

LARAMIE MTS South

LRMS-S. Central	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Mill Creek	85	0	0	0	0	0	0	0	0
Lower Horseshoe Creek	86	0	51	15	0	0	0	0	66
Upper Horseshoe Creek	87	28	329	433	17	0	0	0	807
Roaring Fork	88	0	245	4	15	0	0	0	264
Cottonwood Creek	89	0	126	14	0	0	0	0	140
	Sum	28	751	466	32	0	0	0	1277

LRMS- Southwest	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Eggleston Creek	90	68	479	496	75	0	0	0	1118
Bear Creek	91	67	691	638	8	0	0	0	1404
N. Laramie River	92	0	113	0	15	0	0	0	128
	Sum	135	1283	1134	98	0	0	0	2650

LRMS- Southern	BDU	12 DecFOR	13 ConFOR	14 SHRUB	15 GRS/FRB	16 NonVeg	17 Misc	18 Water	Totals
Claude Irvine Creek	93	9	148	62	0	0	0	0	219
Owen Creek	94	13	26	22	0	0	0	0	61
Dry Laramie River	95	59	1	0	0	0	0	0	60
Luman Creek	96	0	67	3	4	0	0	0	74
	Sum	81	242	87	4	0	0	0	414
Lar. Mts. S. Total	Sum	244	2276	1687	134	0	0	0	4341
Lar. Mts. Total	Sum	486	4306	2223	431	3	0	0	7449
East Side Total	Sum	841	4816	4710	1622	25	0	12	12026
MBNF Total	Sum	4802	24961	31664	4260	98	471	2688	68944

TABLE 7.9 Cover types in riparian areas (Net NFS acres in each Biodiversity Unit and Biodiversity Area). See Fig. 7.2. (cont)

SHERMAN MTS.	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	Totals
Telephone Creek	68	28	57	106	40	0	0	0	231
Lodgepole Creek	69	93	188	916	329	4	0	0	1530
Crow Creek	70	234	265	1465	822	18	0	12	2816
	Sum	355	510	2487	1191	22	0	12	4577

LARAMIE MTS North		12	13	14	15	16	17	18	
LRMN-Northwest	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	Totals
W. Fk. Deer Creek	71	1	86	0	0	0	0	0	87
Bates Creek	72	4	116	1	1	0	0	0	122
Upper Deer Creek	73	106	309	108	29	0	0	0	552
Virden Creek	74	0	14	3	0	0	0	0	17
Box Elder Creek	75	26	186	20	1	0	0	0	233
E. Box Elder Creek	76	2	60	0	50	0	0	0	112
Standing Rock Creek	77	2	3	0	0	0	0	0	5
Meadow Creek	78	13	234	7	78	1	0	0	333
Little Med. Bow River	79	6	101	70	51	0	0	0	228
Sheep Creek	80	2	166	159	63	0	0	0	390
	Sum	162	1275	368	273	1	0	0	2079

		12	13	14	15	16	17	18	
LRMN- N. Central	BDU	DecFOR	ConFOR	SHRUB	GRS/FRB	NonVeg	Misc	Water	Totals
Rocky Ford Creek	81	0	38	0	0	0	0	0	38
Latham Creek	82	0	10	12	0	0	0	0	22
W. Fk. La Bonte Canyon	83	3	35	0	0	0	0	0	38
La Bonte Creek	84	77	672	156	24	2	0	0	931
	Sum	80	755	168	24	2	0	0	1029
Lar. Mts. North	Sum	242	2030	536	297	3	0	0	3108

CONCERNS IN RIPARIAN AREAS

Beavers are common in the Sierra Madre, Medicine Bow and Sherman Mountains. They are few to absent in many watersheds in the Laramie Mountains, where ranchers often hire trappers to remove beavers from private, state and National Forest lands and willows have been removed by livestock and wildlife use. Beaver trapping is regulated within a limited quota area in the Sherman Mountains, but populations are unmanaged and unmonitored everywhere else. Trapping pressures have not been as great in the Sierra Madre and Medicine Bow Mountains as in the Laramie Mountains and riparian areas are well stocked with beaver in the western two ranges. Beaver populations and willow communities increased substantially in lower Douglas Creek after the minimum flow from Rob Roy Reservoir was increased from 1.0 to 5.5 CFS in 1986 (Speas personal communication).

Problems with condition of riparian areas occur mainly in the southwestern Sierra Madre and Laramie Mountains. Long-term grazing and easily erodible soils characterize the southwestern Sierra Madre Mountains. In sections of the Battle Creek valley adjacent to the Savery Stock Driveway, cottonwoods and other shrubs are regenerating poorly due to herbivory and mechanical damage from livestock and wildlife. In the Laramie Mountains the removal of beavers and loss of beaver ponds caused lowering of the water table, allowing livestock and wildlife to penetrate willow carrs resulting in loss of willows and other riparian shrubs due to herbivory and mechanical damage. This scenario of events is common, especially where there is mixed land ownership.

Canyons and long river valleys are characterized by riparian areas subject to flooding and occasional landslides. Additional impacts come from sediment production along roads, vegetation damage or removal by livestock, and recreational use. These disturbances often prevent the development of mid- to late-seral vegetation. Specific problem areas are identified in the Biodiversity Area profiles.

Exotic noxious weeds are a problem in lower elevation riparian areas (Laramie Mountains from LaBonte Canyon southward) and also in the southwestern Sierra Madre and northwestern Medicine Bow Mountains. Efforts are being made to control the spread of musk thistle, Canada thistle, houndstongue, and two species of toadflax in riparian areas. Exotic plant species are discussed in Appendix 5. Some other widespread introduced species found in riparian areas are poison hemlock, dames rocket, alfalfa, yellow and white sweetclover, common dandelion, alsike clover, red clover, white clover, meadow foxtail grass, orchardgrass, smooth brome, timothy, and Kentucky bluegrass. Common dandelion, the clovers, timothy, and Kentucky bluegrass are all aggressive species

resistant to grazing. They are common in heavily grazed riparian areas whether native shrubs (willow, alder, silver sagebrush) persist or not.

Other riparian area problems stem from tie driving and mining activities. Effects of these activities are discussed in Chapter 4.

LITERATURE CITED

Bartelt, P.; Orde, C.J. 1987. Wood frog monitoring. Medicine Bow National Forest Internal Report. 12 pp.

Baxter, G.T. Personal communication. Retired professor - University of Wyoming Zoology Department.

Baxter, T. No date. A key to the common organisms occurring in Telephone Creek, Nash Fork Creek, Nash Fork Creek and the Little Laramie River, Wyoming. University of Wyoming. Laramie.

Baxter, G.T.; Simon, J.R. 1970. Wyoming fishes. Wyoming Game and Fish Department. Bulletin No. 4.

Blake, I.H. 1945. An ecological reconnaissance in the Medicine Bow Mountains. Ecological Monographs 15(3): 208-242.

Bozek, M.A.; Young, M.K. 1994. Fish mortality resulting from delayed effects of fire in the Greater Yellowstone Ecosystem. Great Basin Naturalist 54(1): 91-95.

Condor A.; McKnight, R. 1990. A fisheries survey of the Horseshoe Creek drainage, tributary to the North Platte River, Platte, Albany and Converse County. Wyoming Game and Fish Department Administrative Report 256-6. Cheyenne, WY.

Cummins, K.W. 1973. Trophic relations of aquatic insects. Annual Review of Entomology 18:183-206.

Dean, D. et al. 1995. Coarse filter analysis of Ecosection M331I. Contract between U.S. Forest Service, Region 2 and Colorado State University. GIS Maps

Debrey, L.D.; Lockwood, J.A. 1988. Effects of sediment and flow regime on the aquatic insects of a high mountain stream. Regulated Rivers: Research and Management. 5: 241-250.

Garber, C.S. 1994. A status survey for spotted frogs (*Rana pretiosa*), wood frogs (*Rana sylvatica*), and boreal toads (*Bufo boreas*) in the mountains of southern and eastern Wyoming. 53 pp.

Gibbons, D.R.; Salo, E.O. 1973. An annotated bibliography of the effects of logging on fish of the western United States and Canada. USDA Forest Service General Technical Report PNW-10.

Giles, G.H. 1933. Algae of the Medicine Bow Mountains in the vicinity of the University summer camp. Master's Thesis. University of Wyoming. Laramie, WY.

Good, W.R. 1974. Some effects of mountain snowmelt runoff on aquatic invertebrate populations in a high mountain streams. Ph.D. dissertation. University of Wyoming. Laramie, WY.

Gumtow, R.; Dirienzo,, B; Frederick, K. 1994. 1994 Wyoming Water Quality Assessment. Water Quality Division, Wyoming Department of Environmental Quality. Cheyenne, WY.

Guenther, P.K. 1989. Minimum pool requirements for the enhancement and maintenance of salmonid fisheries in small Wyoming impoundments. Master's Thesis. University of Wyoming. Laramie, Wyoming.

Hensey, R.J. 1993. Sedge, hairgrass and reedgrass response after two years of streamflow augmentation. Ph.D. Dissertation. University of Wyoming, Laramie, WY

Hepworth, W.G. 1959. A study of the population dynamics of brook trout in the two alpine lakes in southeastern Wyoming. Master's Thesis. University of Wyoming. Laramie, WY.

Hynes, H.B.N. 1970. The ecology of running water. University of Toronto Press.

Jones, G. 1992. A preliminary classification of riparian vegetation types of the Medicine Bow Range and the Sierra Madre. Cost Share Agreement 0206-90-01. Medicine Bow National Forest. Laramie, WY.

Kimble, L.A.; Wesche, T.A. 1975. Relationships between selected physical parameters and benthic community structure in a small stream. Water Resource Series No. 55. Water Resources Research Institute. University of Wyoming. Laramie, WY.

Kozel, S.J. 1987. Trends in habitat features and trout abundance among unaltered stream reaches on the Medicine Bow National Forest. Master's thesis. University of Wyoming. Laramie, Wyoming.

Mastel, J. 1995. Riparian classification of the Brush Creek District, Northwestern Medicine Bow Mountains (In progress).

McDowell, R. 1975. A study of the Pole Mountain fishery: beaver ponds, artificial impoundments and stream investigations. Wyoming Game and Fish Department Administrative Report F-44-R-01. Cheyenne, WY.

McMillan, J. 1989. A fishery and habitat survey of the Deer Creek drainage, Converse and Natrona Counties, WY. Wyoming Game and Fish Department Administrative Report. Cheyenne, WY.

McMillan, J. 1990. A fishery and habitat survey of the La Prele Creek drainage, Converse County, WY. Wyoming Game and Fish Department Administrative Report. Cheyenne, WY.

Miller, D. personal communication. Wyoming Game and Fish Department

Miller, A.I. 1989. Geomorphic controls on winterkill conditions in lakes of the Snowy Range, Wyoming. Master's thesis. University of Wyoming. Laramie, Wyoming.

Minshall, G.W.; Petersen, R.C.; Cummins, K.W.; Bott, T.L.; Sedell, J.R.; Cushing, C.E.; Vannote, R.L. 1983. Interbiome comparison of stream ecosystem dynamics. Ecological Monographs 53:1-25.

Musselmen, R.C. (technical coordinator). 1992. The glacier lakes ecosystem experiments site. General Technical Report RM-249. Fort Collins, CO: USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. 94 p.

Oberholtzer, M. 1985. A comprehensive survey of the Medicine Bow River Drainage, tributary to the North Platte River, Carbon County, Wyoming. Wyoming Game and Fish Department Administrative Report 5084-01-7201. Cheyenne, WY.

Oberholtzer, M. 1989. Fisheries management plan for Douglas Creek, a Class II stream in Albany and Carbon County, Wyoming. Wyoming Game and Fish Department Administrative Report 5088-21-8401. Cheyenne, Wyoming.

Payne, F.E. 1983. Response of phytoplankton and zooplankton to nutrient enrichment in Big Brooklyn Lake, Wyoming. Ph.D. Dissertation. University of Wyoming. Laramie, WY.

Reyes, M. 1994. Invertebrates as indicators of biotic integrity in montane wetlands. Proposal to the Department of Zoology and Physiology. University of Wyoming. Laramie, WY.

Royer, L.M. 1960. A study of the ecology of the brook trout in Little Brooklyn Lake, Medicine Bow Forest, Wyoming. Master's Thesis. University of Wyoming. Laramie, WY.

Schullery, P.; Varley, J.D. 1994. Fires and fish - the fate of Yellowstone waters since 1988. Trout. Publication of Trout Unlimited.

Seaber, P.R.; Kapinos, F.P.;Knapp, G.L. 1987. Hydrologic unit maps. U.S. Department of the Interior Geological Survey. Water Supply Paper 2294. Denver, CO.

Simon, F. 1938. A survey of the lakes and streams in the Medicine Bow National Forest, Wyoming. Master's Thesis. University of Wyoming. Laramie, WY.

Snigg, M.A. 1986. Pole Mountain beaver pond re-inventory. Wyoming Game and Fish Department Administrative Report 5085-13-7301. Cheyenne, WY.

Snigg, M.A. 1989. Snowy Range lake survey. Wyoming Game and Fish Department Administrative Report. 5089-01-8701. Cheyenne, WY.

Sullivan, K.; Lisle, T.E.; Dolloff, C.A.; Grant, G.E.; Reid, L.M.. 1987. Stream channels: the link between forests and fishes. IN: Streamside Management: Forestry and Fishery Interactions. Salo and Candy (editors).

Swanston, D.A. 1991. Natural processes. IN: Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitat. American Fisheries Society Special Publication 19. Bethesda, Maryland.

von Ahlefeldt, J.P. 1992. Riparian classification for the Laramie Mountains, Douglas Ranger District (In preparation).

Wesche, T.A. 1987. Habitat restoration plan for Douglas Creek. USDA Forest Service. Medicine Bow National Forest. 42 pp.

Williams, J.E.; Neves, R.J. 1992 Special Session 6. Biological diversity in aquatic management - Opening remarks. In: Biological Diversity in Aquatic Management. Trans. 57th North American Wildlife and Natural Resources Conference.

Williams, J.E.; Rinne, J.N. 1992. Essay: Biodiversity management on multiple-use federal lands: An opportunity whose time has come. Fisheries Vol.17. No. 3:4-5.

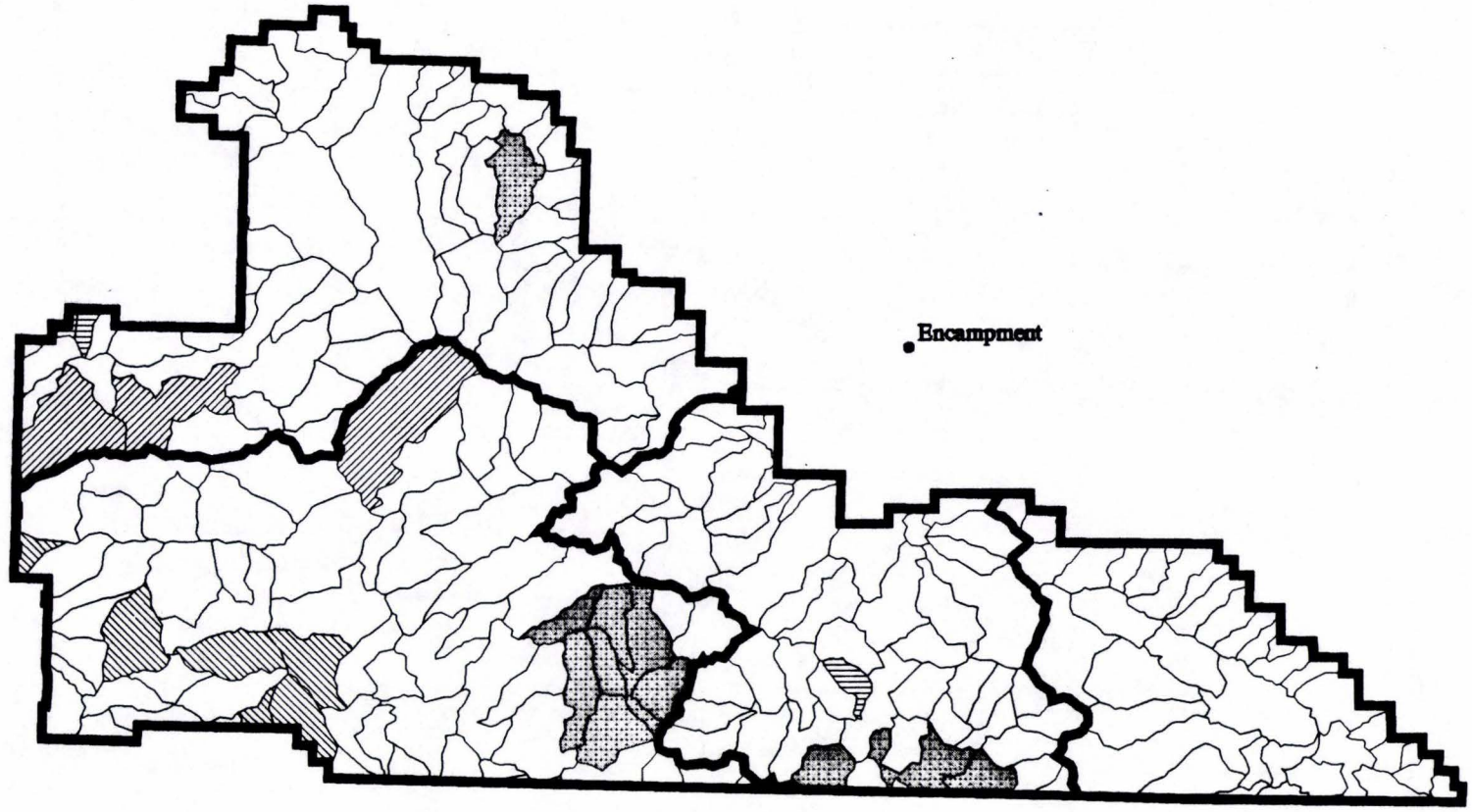
Young, M. K.; Haire, D.; Bozek, M.A. 1994. The effect and extent of railroad tie drives in streams of southeastern Wyoming. Western Journal of Applied Forestry. 9(4): 125-130.

MEDICINE BOW NATIONAL FOREST

SIERRA MADRES

Watersheds of Concern

FIGURE 7.1a



LEGEND

- Ground validation shows stream channels in poor condition.
- 30 percent or more of the watershed area is covered with polygons from the Wyoming Landslide Classification Maps.
- The watershed has a weighted average soils k-factor of .35 or more.
- Cummulative disturbed area in the watershed, adjusted for recovery, is 25% or more.
- Watershed does not meet State water quality standards due to point source pollution sites.
- 8th Level Watershed Boundary
- Biodiversity Area Boundary

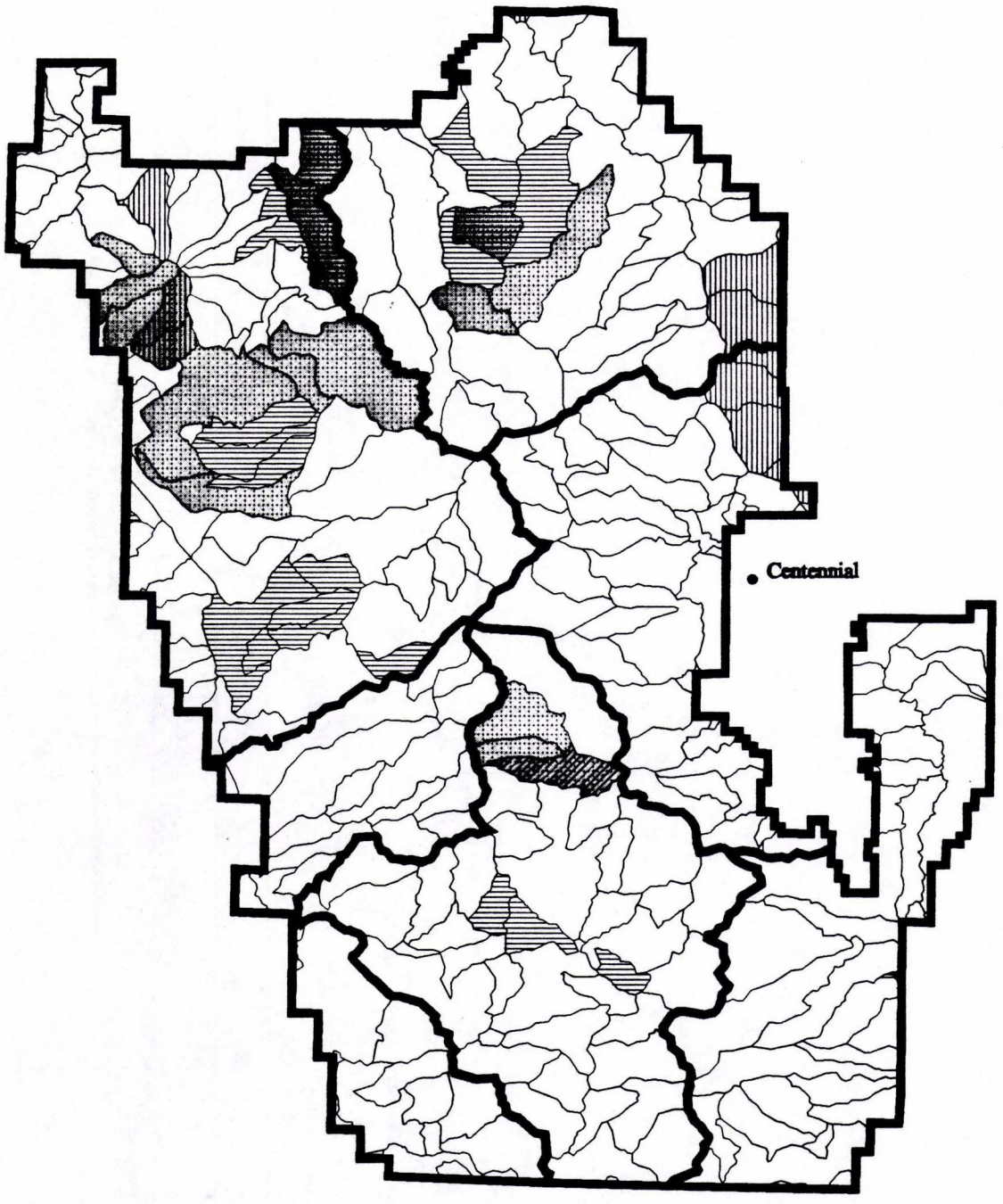
Scale 1 to 375,000

Created by CLT for CS, 02.28.95, con_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Watersheds of Concern

FIGURE 7.1b



Created by CLT for CR, 02.28.95, cen snowy.aml

LEGEND

- Ground validation shows stream channels in poor condition.
- 30 percent or more of the watershed area is covered with polygons from the Wyoming Landslide Classification Maps.
- The watershed has a weighted average soils k-factor of .35 or more.
- Cummulative disturbed area in the watershed, adjusted for recovery, is 25% or more.
- Watershed does not meet State water quality standards due to point source pollution sites.
- 8th Level Watershed Boundary
- Biodiversity Area Boundary

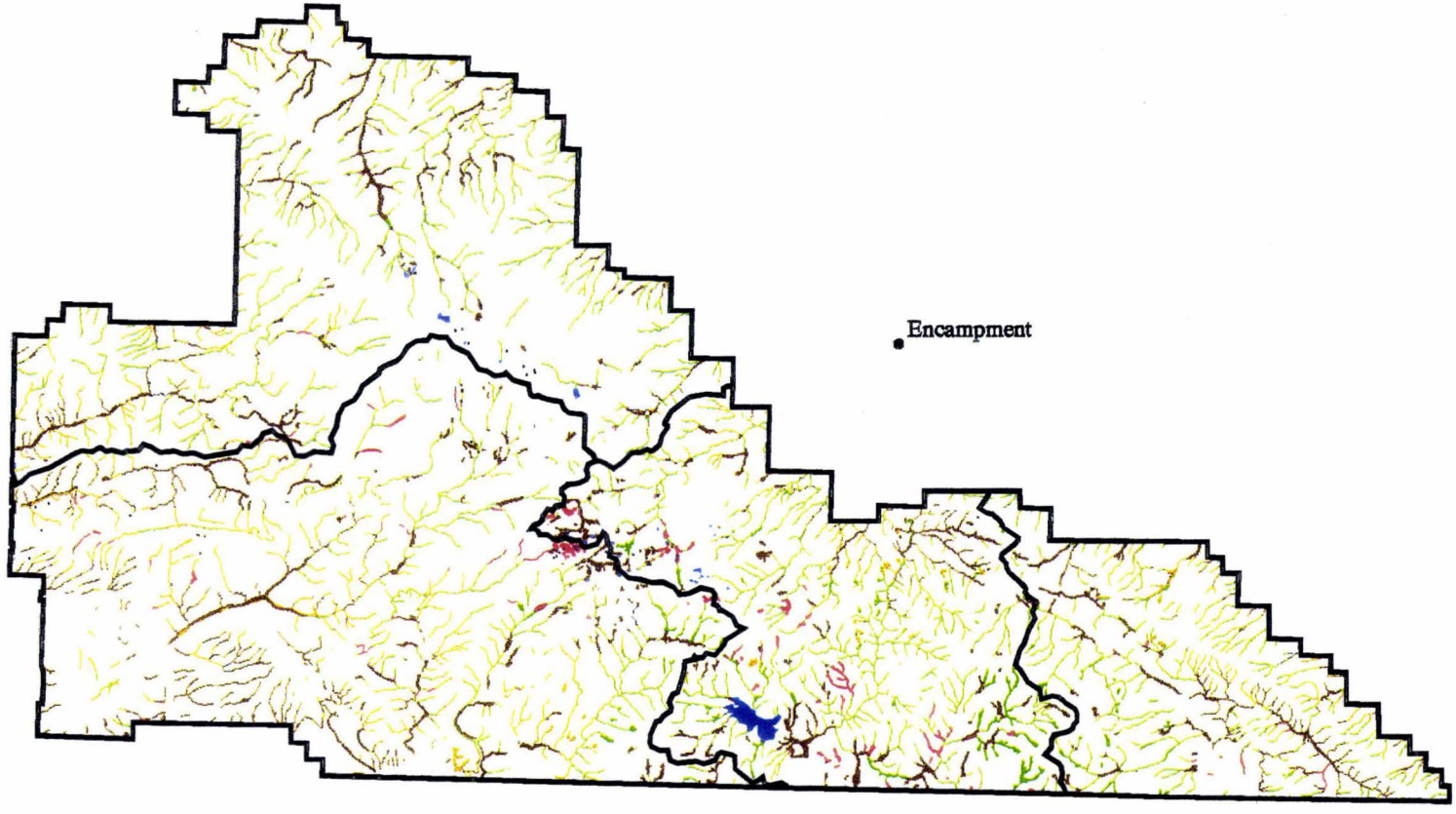
Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Riparian Cover Type Map

SIERRA MADRES

FIGURE 7.2a



- Riparian Deciduous Forest
- Riparian Coniferous Forest
- Riparian Shrubland
- Riparian Grassland/ Forbland
- Riparian Non-vegetated
- Misc. Wetlands
- Water
- Biodiversity Area Boundary

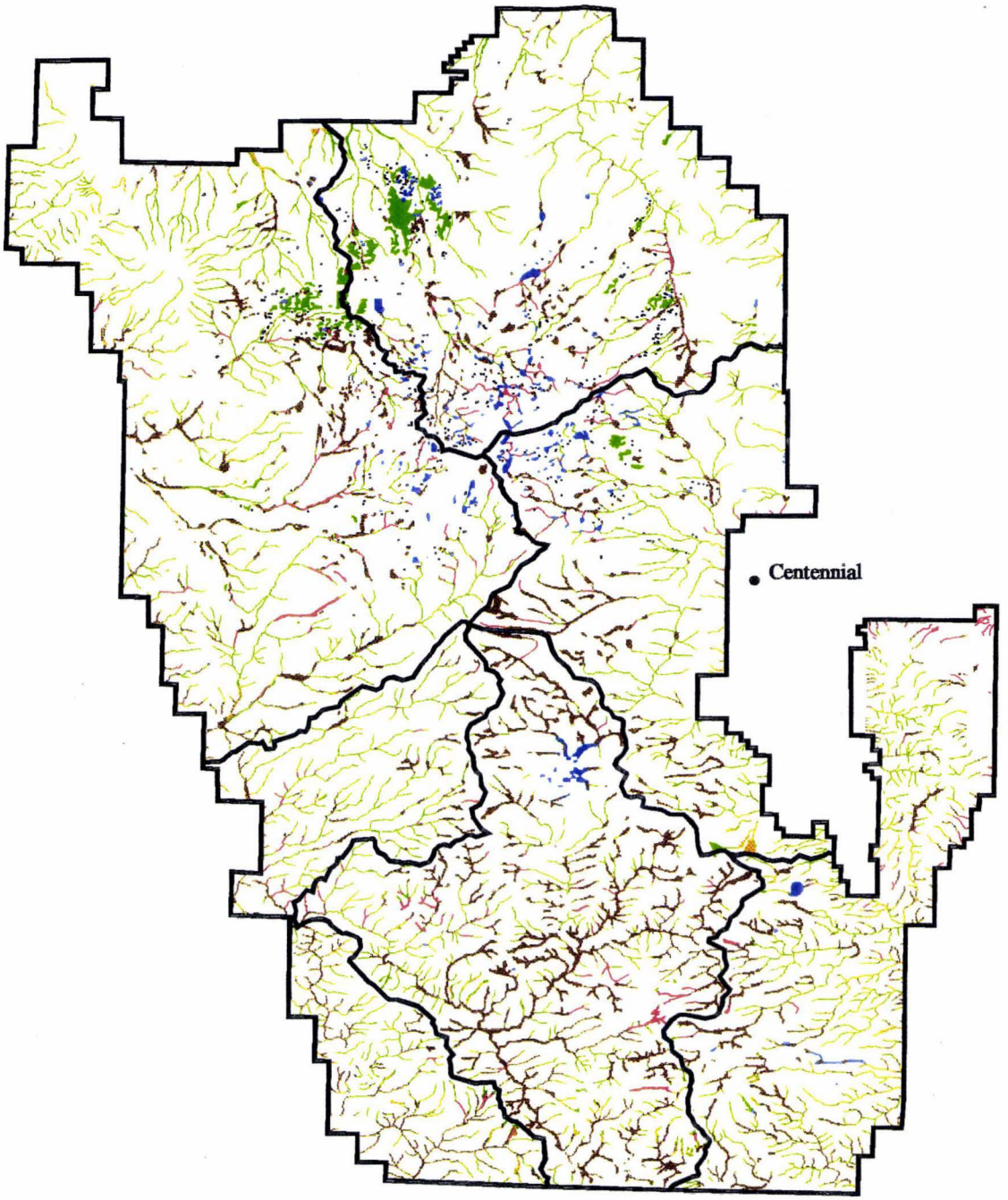
Scale 1 to 375,000

Created by CLT for JVA, 03.06.95, rip_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Riparian Cover Type Map

FIGURE 7.2b



Created by CLT for JVA, 03.06.95, rip_snowy.aml

LEGEND

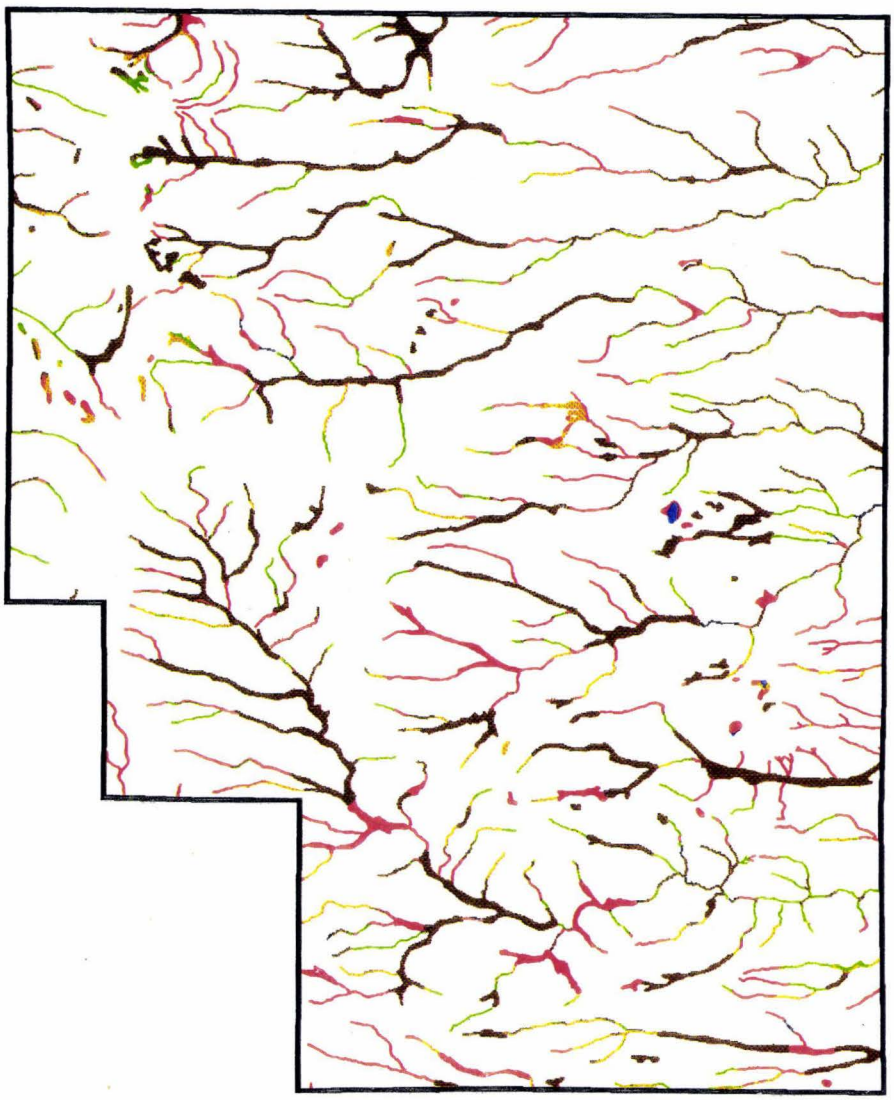
- Riparian Deciduous Forest
- Riparian Coniferous Forest
- Riparian Shrubland
- Riparian Grassland/ Forbland
- Riparian Non-vegetated
- Misc. Wetlands
- Water
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Riparian Cover Type Map

FIGURE 7.2c



Created by CLT for JVA, 03.07.95, rip_sherman.aml

LEGEND

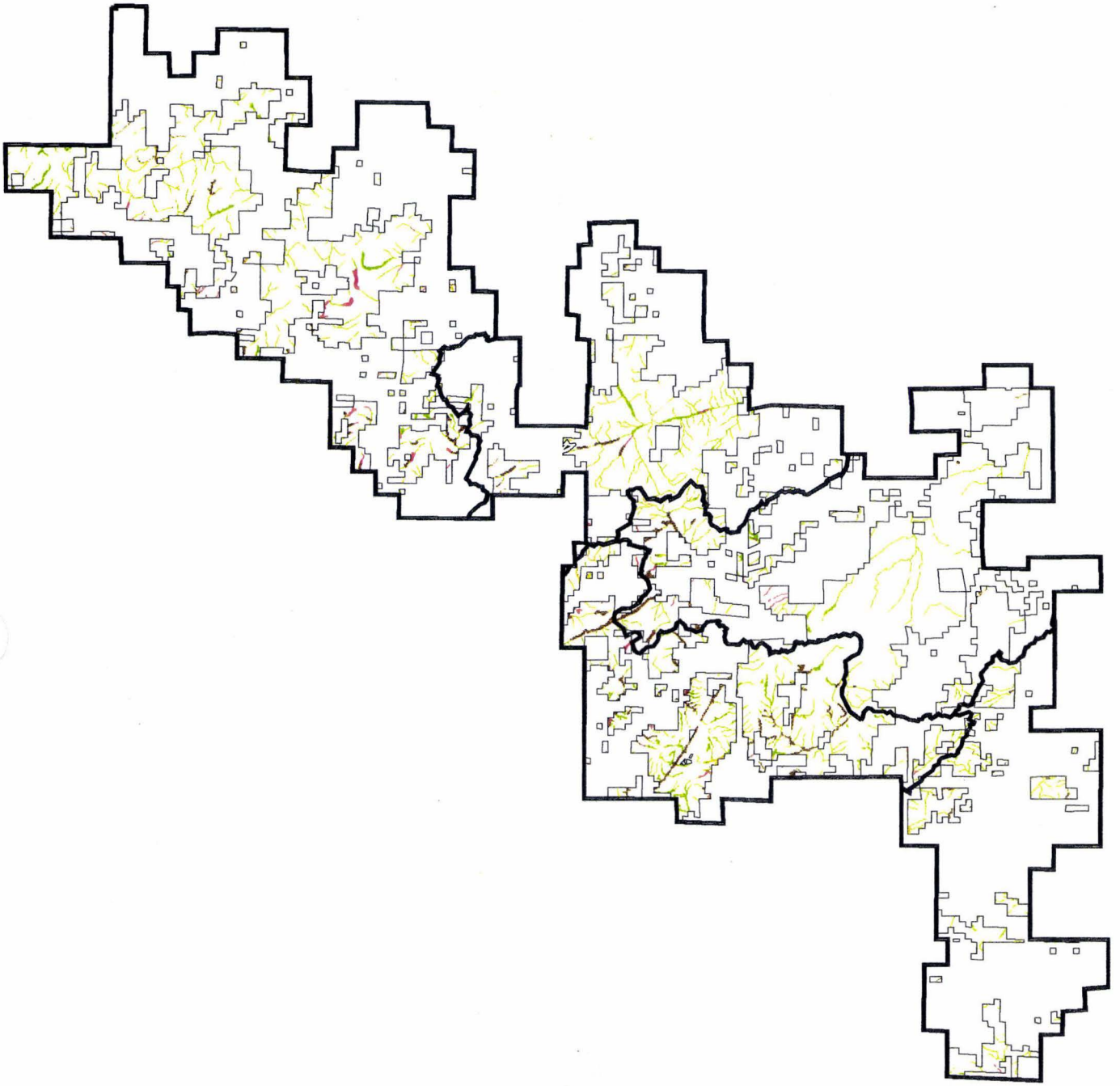
- Riparian Deciduous Forest
- Riparian Coniferous Forest
- Riparian Shrubland
- Riparian Grassland/ Forbland
- Riparian Non-vegetated
- Misc. Wetlands
- Water
- Biodiversity Area Boundary

Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST — LARAMIE RANGE

Riparian Cover Type Map

FIGURE 7.2d



Created by CLT for JVA, 03.07.95, rip laramie.aml

LEGEND

- Riparian Deciduous Forest
- Riparian Coniferous Forest
- Riparian Shrubland
- Riparian Grassland/ Forbland
- Riparian Non-vegetated
- Misc. Wetlands
- Water
- Biodiversity Area Boundary
- Forest Administrative Boundary

Scale 1 to 425,000

CHAPTER 8

BIOLOGICAL DIVERSITY OF SPECIES AND GENES

INTRODUCTION

This chapter includes discussion of species diversity, genetic diversity, and species relationships to habitats at the fine filter analysis level. Species on the US Fish and Wildlife Service (USFWS) Threatened, Endangered, and (former) Candidate lists and Region 2- Sensitive Species (TECS species) are discussed. Additional species of concern to the Nature Conservancy and to conservation groups are recognized. Species abstracts containing information on local distribution of TECS species are included. National and Regional direction for conservation of neotropical migratory birds (NTMB) is detailed. The chapter concludes with summaries of information on big-game species and large predators.

Description and management of biological diversity is concerned with all species, not just those native populations which are nationally, regionally or locally declining or in danger of extinction or extirpation. Species richness on the Medicine Bow National Forest includes at least 351 vertebrate animals and 1162 species of higher plants. Species counts for invertebrates, fungi, and lichens were not attempted, but available information on these organisms is found in Appendices 7 and 8 and in Chapter 7.

Lists of all higher plant and animal species documented, or likely to presently occur on the MBNF are in Appendices 4 and 9. Occurrence of vertebrate species and plants is grouped by mountain range in the Appendix tables and supported by additional discussion and documentation. Lichen and fungal species are discussed in Appendices 7 and 8. Exotic (non-native) plants are discussed in Appendix 5 and the diversity of plant community types on the MBNF, listing major overstory and understory species, is in Appendix 6.

With available time and personnel it was not possible to review and synthesize all of the pertinent literature on species biology and species-habitat relationships on the Medicine Bow National Forest. More analysis needs to be done to review this literature and relate what is known about specific habitat relationships to alterations associated with management activities or natural disturbance.

Several native species of particular interest because of restricted ranges and low populations are: 1) Colorado River cutthroat trout (endemic to the Green River drainage in Wyoming (nearly half of the known genetically high purity populations occur in the Sierra Madre Mountains of the MBNF, 2) the Laramie

columbine (endemic to the Laramie Mountains), 3) Weber's Ipomopsis (the only known occurrence in Wyoming is in the Sierra Madre Mountains, although the species range extends from northern Idaho to Northern Colorado). Populations of most other TECS species are more widely distributed, occur in Wyoming as disjunct populations which are widespread elsewhere, or breed here but winter in other areas (many birds). The only Federally Listed (Threatened or Endangered species) are the bald eagle and peregrine falcon. Limited habitat for these species is found on the Medicine Bow National Forest.

INVERTEBRATE SPECIES DIVERSITY IN REPRESENTATIVE ECOSYSTEMS

In the summers of 1933, '35, and '36, Dr. Irving H. Blake, Department of Zoology and Anatomy of the University of Nebraska, supervised extensive fieldwork to determine invertebrate species composition of 12 ecosystems in the higher elevations of the Medicine Bow Mountains. Fifty-five invertebrate specialists assisted with species identification. These included eminent zoologists such as R.E. Coker, James Needham, and P.W. Claassen. Blake presented his findings as an introduction to some animal communities of the Medicine Bow National Forest, hoping that it would be a stimulus for more detailed ecological studies. It was a study of biological diversity far ahead of its time and is a benchmark paper on invertebrate community ecology in the southern Rocky Mountains (Blake 1945).

AQUATIC ECOSYSTEMS	TERRESTRIAL ECOSYSTEMS
Small Swift Stream	Rocky Slope
Large Swift Stream	Alpine Grassland
Large Pond	Aspen Forest
Moraine Pond	Lodgepole Pine Forest
Temporary Pond	Spruce-fir Forest

RIPARIAN ECOSYSTEMS
Wet Meadow
Willow Bog

The 12 communities were located in the vicinity of the University Science Camp along Highway 230 on the Nash Fork Drainage. The 700-acre Snowy Range Research Natural Area (not designated until 1937) hosted most of the sites except for the moraine ponds (kettleholes) and the rocky slope which were located respectively north of Highway 230 and north of the Science Camp. The moraine

ponds area has been identified as a potential Research Natural Area site (Jankovsky-Jones et al. 1994).

Species diversity of invertebrate fauna, (and incidental vertebrates) of aquatic, riparian and terrestrial communities of high-altitude ecosystems of the Medicine Bow Moutains are listed in Table 8.1. Two key points from this study are:

1. the contribution of seasonal wetlands to biological diversity of high elevation ecosystems

2. the high level of invertebrate species diversity in old spruce-fir forest dependent on complex cycles of decay in a variety of moist microhabitats containing mosses, lichens and fungi. These microecosystems contain a multitude of inconspicuous invertebrates.

Common names in Table 8.1 are updated from Blake's lists.

Table 8.1. Synopsis of high elevation communities. From Blake (1945).

AQUATIC COMMUNITIES

SMALL SWIFT STREAM COMMUNITY
9,700 feet in spruce-fir forest

Mammals	-
Birds	-
Reptiles	-
Amphibians	-
Fish	cutthroat trout, brook trout
Arthropods	midges (2 species), black flies, caddisflies, stoneflies (2 species), damselflies (5 species), mayflies (3 species)
Mollusks	-
Flatworms	planarian worm

LARGE SWIFT STREAM COMMUNITY
9,775 feet in spruce-fir forest

Mammals	beaver
Birds	dipper
Reptiles	-
Amphibians	-
Fish	cutthroat trout
Arthropods	midges, crane-flies (2 species), caddisflies, (3 species), stoneflies (3 species), damselflies (4 species), mayflies (2 species), fresh-water mites
Mollusks	-
Flatworms	-

LARGE POND COMMUNITY
10,000 feet - Swastika Lake

Mammals	-
Birds	-
Reptiles	-
Amphibians	boreal toad
Fish	cutthroat trout
Arthropods	caddisflies, diving beetles (3 species), water strider, back-swimmer, fresh-water mite, scud, copepod
Mollusks	clam (2 species)
Flatworms	leeches (2 species)

Table 8.1. continued

MORAINE POND COMMUNITY 10,200 feet in spruce-fir forest	
Mammals	-
Birds	-
Reptiles	-
Amphibians	swamp cricket frog
Arthropods	mosquitoes (2 species), caddisflies, long-horned leaf beetle, whirligig beetle, predaceous diving beetle (2 species), water strider (2 species), damselfly (2 species) skimmer, dragonfly (3 species), copepod, fairy shrimp
Mollusks	-
Flatworms	leech
TEMPORARY POND COMMUNITY 9,700 feet	
Mammals	-
Birds	spotted sandpiper
Reptiles	-
Amphibians	leopard frog, boreal toad
Arthropods	caddisflies (2 species), diving beetles (6 species), water boatmen, dragonflies, mayflies, water mites (4 species)
Mollusks	pond snail (2 species)
Flatworms	planarian worm
RIPARIAN COMMUNITY	
WET MEADOW COMMUNITY 9,700 feet	
Mammals	western jumping mouse, vole, pocket gopher
Birds	-
Reptiles	-
Amphibians	Rocky Mountain toad
Arthropods	sawfly, muscid fly, kelp fly, dung fly, frit fly, shore fly, lonchaeid fly, dance-fly, long-legged fly, midge, lady-bird beetle, cantharid beetle (2 species), ground beetle (2 species), lantern fly, leaf bug (2 species), wolf spider (2 species)
Mollusks	-
Flatworms	-

Table 8.1. continued

WILLOW BOG COMMUNITY 10,500 feet	
Mammals	-
Birds	-
Reptiles	-
Amphibians	-
Arthropods	muscid fly, water-scavenger beetle, predaceous diving beetle, jumping plant louse (5 species), water strider, spider, copepod, water flea (3 species)
Mollusks	-
Flatworms	Planarian worm
TERRESTRIAL COMMUNITIES	
ROCKY SLOPE COMMUNITY 9875-11,000 feet or more -scree and old burn	
Mammals	pika, yellow-belled marmot
Birds	water pipet, rosy finch
Reptiles	-
Amphibians	-
Arthropods	mason bee, carpenter ant, ant, ichneumon fly, tachina fly, flesh fly, muscid fly, shore fly, march fly, owlet moth, leafhopper, leafhopper beetle (3 species), snout beetle, clear-winged locust, centipede, mite, jumping spider, orb-web spider, wolf spider
Mollusks	-
ALPINE GRASSLAND COMMUNITY 9850 - 12,000 feet	
Mammals	golden-mantled ground squirrel
Birds	American kestrel, red-tailed hawk, white-tailed ptarmigan, bald eagle[1]
Reptiles	-
Amphibians	-
Arthropods	bumblebee, anthroporid bee, pangurid bee, ant, chalcid fly, flesh fly (2 species), fruit fly, soldier fly, mosquito, tortoise shell butterfly, white-lined sphinx, ground beetle, plant louse, leafhopper, lygaeid bug, tarnished plant bug, jumping spider, millipede
Mollusks	-

Table 8.1. continued

	ASPEN FOREST COMMUNITY 9,000 feet
Mammals	bushy-tailed woodrat
Birds	mountain bluebird, Townsend's warbler, cliff swallow[1]
Reptiles	-
Amphibians	-
Arthropods	carpenter ant, ant, ichneuman fly, muscid fly, frit fly, stilletto-fly, soldier fly, leaf-beetle, long-horned beetle, lady bird beetle (2 species), click beetle (2 species), canthard beetle, ground beetle (5 species), leafhopper, neuropteran,jumping spider, wolf spider
Mollusks	-
	LODGEPOLE PINE FOREST COMMUNITY 9,500 feet
Mammals	deer mouse
Birds	-
Reptiles	-
Amphibians	-
Arthropods	carpenter ant, ant (2 species), blood-red slave-maker ant, ichneumon fly, muscid fly (2 species), hump-backed fly, stilletto fly, dark-winged fungus-gnat, black fly, click beetle, ground beetle, wolf spider, centipede
Mollusks	-
	SPRUCE-FIR FOREST COMMUNITY 9,800 - 11,000 feet
Mammals	mule deer, elk, snowshoe hare, porcupine, red squirrel, least chipmunk, long-tailed weasel, marten, bat
Birds	American robin, hermit thrush, ruby-crowned kinglet, mountain chickadee, dark-eyed junco, white-crowned sparrow, pine siskin, Clark's nutcracker, gray jay, Lewis's woodpecker[1]
Reptiles	-
Amphibians	-
Arthropods	cuckoo bee, wasp, ant, ichneumon fly (2 species), sawfly, (3 species), muscid fly (2 species), flower fly, stilletto fly, horse fly, moth fly, crane fly, owlet moth, leaf beetle, long-horned beetle (3 species), click beetle, bark beetle, melyrid beetle, rove beetle, ground beetle, stonefly, mayfly, spring-tail, wolf spider, funnel-web spider, crab-spider, orb-web spider, other spiders (3 species), harvestman, centipede (2 species), mite
Mollusks	-

[1] not characteristic of these ecosystems

THREATENED OR ENDANGERED SPECIES, (FORMER) CANDIDATE SPECIES, AND REGION 2 SENSITIVE SPECIES

FLORA

No Federally Listed plant species occur on th MNBF. Three former C2 species are the Laramie columbine, Weber's ipomopsis, and clustered lady's slipper. These three species and the Colorado tansy aster are R-2-Sensitive Species known to occur on the MBNF. Three other R-2 Sensitive Species (Colorado aletes, rough fescue, Laramie false sagebrush) may occur within the National Forest boundary, but documentation is lacking. See the *Handbook of Medicine Bow National Forest Sensitive Plant Species* (von Ahlefeldt 1993) and *Wyoming Rare Plant Field Guide* (Fertig 1994a).

FAUNA

Data on faunal populations are sparse and poorly distributed for most TECS species. Most sightings are from areas with roads. Many records for marten and northern goshawk are from areas coincident with timber sales. Some records consist of only sightings, while others include data on nest sites, age or sex. Some records may count the same animal twice or more.

Generally records are a function of the distance from Laramie - the farther the distance, the fewer the records. Current data on the presence of TECS species must be interpreted with caution and should not be considered as a substitute for needed systematic surveys and monitoring for populations of these species.

Because data are so fragmented through time and space and few systematic surveys have been made to assess populations for each of the mountain ranges, population sizes remain unknown and trend assessment is difficult to impossible. It is not possible at this time to determine specific effects of management activities or natural disturbances on these species.

At best, most faunal records suggest a sketchy outline of where these organisms are found. For a few species (Colorado River cutthroat trout, boreal toad, wood frog, northern goshawk, and marten) specific areas have been surveyed or specific populations studied. Surveys for listed species have been conducted by Districts in the past few years. Many TECS surveys have been mainly in conjunction with site-specific timber sales and do not include the entire MBNF. District-wide surveys have been done for Federally Listed species over the past few decades.

Species identified as potentially occurring on the MBNF by the USFWS (Davis 1995), but which are not known to occur are (Federally Listed) - Whooping

crane, black-footed ferret, Wyoming toad and Ute's ladies tresses; (former Candidate 2) - swift fox, ringtail, North American lynx, eastern spotted skunk, Preble's jumping mouse, western snowy plover, and plains topminnow.

TABLES

Tables 8.2 - 8.7 sumarize the following information:

8.2 Species which are federally listed as threatened or endangered as of August 20, 1994 (Federal Register 1994)

8.3 Former candidate species (C1, C2, C3) listed by the U.S. Fish and Wildlife Service as of August 24, 1994 (Federal Register 1994)

8.4 Species on the Region 2 Regional Foresters Sensitive Species List (April, 1994)

8.5 Plant species of concern to the Nature Conservancy

8.6 Animal species of concern to the Nature Conservancy

8.7 Species of concern to conservation groups, documented in correspondence to the MBNF (Stansfield et al. 1992; Biodiversity Legal Foundation 1993).

Discussion of distribution of TECS species in Biodiversity Areas (groups of watersheds) before and after 1985 is in Appendix 17.

Table 8.2 Federally threatened or endangered species known from the Medicine Bow National Forest (Federal Register 1994)

	Sierra Madre	MedB Mtns.	Sh Mtns.	Laramie Mtns.
BIRDS				
bald eagle	X	X	-	X
peregrine falcon	X	X	-	X

Table 8.3 USFWS former Candidate species known from the Medicine Bow National Forest (Federal Register 1994).

PLANTS	C1	C2	C3
Laramie columbine		X	
clustered lady's slipper		X	
Weber's Ipomopsis		X	
ANIMALS			
FISHES			
Colorado River cutthroat trout		X	
AMPHIBIANS			
boreal toad		X	
REPTILES			
eastern short-horned lizard		X	
MAMMALS			
small-footed myotis		X	
long-eared myotis		X	
fringe-tailed myotis		X	
long-legged myotis		X	
Townsend's big-eared bat		X	
BIRDS			
white-faced ibis		X	
northern goshawk		X	
ferruginous hawk		X	
Columbian sharp-tailed grouse		X	
long-billed curlew		X	
mountain plover	X		
black tern		X	
burrowing owl		X	
olive-sided flycatcher		X	
loggerhead shrike		X	
Baird's sparrow		X	

Table 8.4 USFS Region 2-sensitive species

FLORA	Sierra Madre	MedB Mtns.	Sh Mtns.	Laramie Mtns.
SHRUBS				
autumn willow			X	
FORBS				
Laramie columbine				X
clustered ladyslipper	X	X		
Weber's ipomopsis	X			
Colorado tansy aster	X			
FAUNA				
FISHES				
Colo. River cutthroat trout	X	X		
AMPHIBIANS				
tiger salamander	X	X	X	X
boreal toad		X	X	X
leopard frog	X	X	X	X
wood frog	X	X		
REPTILES				
pale milk snake	X			X
MAMMALS				
pygmy shrew		X		
dwarf shrew	X	X	X	X
fringe-tailed myotis			X	X
Townsend's big-eared bat	X	X	X	X
marten	X	X	X	X

Table 8.4 continued

	Sierra Madre	MedB Mtns.	Sh Mtns.	Laramie Mtns.
BIRDS				
common loon		X	X	X
American bittern	X	X	X	X
white-faced ibis			X	
osprey	X	X		X
northern goshawk	X	X	X	X
ferruginous hawk	X	X	X	X
sandhill crane	X	X	X	
Columbian sharp-tailed grouse	X			
black tern			X	
flammulated owl		X	X	X
burrowing owl		X	X	
boreal owl		X		
black swift	X	X		
Lewis' woodpecker		X	X	X
northern 3-toed woodpecker	X	X	X	X
olive-sided flycatcher	X	X	X	X
purple martin	X	X	X	X
pygmy nuthatch	X	X	X	X
golden-crowned kinglet	X	X	X	X
loggerhead shrike	X	X	X	X
fox sparrow	X	X	X	
merlin	X	X		X
upland sandpiper		X		X

Table 8.5 Plant species of special concern (Wyoming Natural Diversity Database 1994).

	Sierra Madre	MedB Mtns.	Sh Mtns.	Laramie Mtns.
TREES	0	0	0	0
SHRUBS	0	1	2	2
FORBS	15	23	8	9
GRAMINOIDS	5	7	2	0
FERN & NON-VASC	1	3	0	0
TOTAL	**21**	**34**	**12**	**11**

	Sierra Madre	MedB Mtns.	Sh Mtns.	Laramie Mtns.
SHRUBS				
Ceanothus fendleri				X
Jamesia americana			X	
Salix candida		X	X	
Salix irrorata				X
FORBS				
Artemisia pattersonii		X		
Aster borealis			X	
Aster porteri			X	
Astragalus leptaleus	X			
Bahia dissecta			X	X
Besseya alpina		X		
Botyrichium lunaria		X		
Botyrichium multifidum	X			
Campanula uniflora		X		
Chenopodium capitatum		X		
Chinophila jamesii	X	X		
Cymopteris alpinus		X		
Draba spectabilis var *oxyloba*	X			
Erigeron elatior	X	X		X
Erigeron melanocaphalus	X	X		
Erigeron pinnatisectus	X	X		
Eriogonum exilifolium	X	X		
Gentiana affinis var *bigelovii*			X	
Gentianella tenella		X		
Haplopappus pygmaeus		X		
Ipomopsis tenuituba		X		X
Lesquerella alpina var *parvula*	X			
Lomatium bicolor var *leptocarpum*	X			

Table 8.5 continued

	Sierra Madre	MedB Mtns.	Sh Mtns.	Laramie Mtns.
Lomatogonium rotatum		X	X	
Mertensia brevistyla	X			
Mimulus breweri				X
Paronychia pulvinata		X		
Petasites sagittatus		X	X	X
Phacelia denticulata		X		X
Physaria vitulifera	X			
Polemonium brandegei			X	X
Prenanthes racemosa				X
Pyrrocoma crocea var *crocea*		X		
Saxifraga chrysantha		X		
Senecio bigelovii var *hallii*	X	X		
Senecio crocatus		X		
Sidalcea candida var *glabrata*	X	X		
Talinum parviflorum			X	
Trillium ovatum	X			
GRAMINOIDS				
Dicanthelium linaerifolium				X
Carex diandra		X		
Carex egglestonii	X	X		
Carex gynocrates	X	X		
Carex limosa	X			
Carex occidentalis	X	X		
Carex oreocharis		X	X	
Carex paupercula		X		
Carex sartwelii			X	
Juncus filiformis	X			
Juncus triglumis		X		
FERNS & NONVASCULAR				
Asplenium trichomanes-ramosum		X		
Athyrium americanum		X		
Gymnocarpium dryopteris	X			
Selaginella mutica		X		

TABLE 8.6 Animal species of special concern (Wyoming Natural Diversity Database 1994)

FISHES	2
AMPHIBIANS	2
REPTILES	1
MAMMALS	9
BIRDS	13

See WYNDD records for occurrences

FISHES	**MAMMALS**	**AMPHIBIANS**
Colorado River	long-legged myotis	boreal toad
cutttroat trout	red bat	wood frog
	pygmy shrew	
	dwarf shrew	
	pika	

BIRDS	**BIRDS**
bald eagle	Lewis' woodpecker
northern goshawk	flammulated owl
boreal owl	osprey
merlin	3-toed woodpecker
peregrine falcon	Columbian sharp-tailed grouse
commmon loon	

Table 8.7 Species of concern to conservation groups

Species of concern to conservation groups specifically cited by Friends of the Bow in *From New Perspectives to Ecosystem Management on the Medicine Bow National Forest*: An Analysis of Problems and Opportunities (Stansfield, 1992); and in a letter from the Biodiversity Legal Foundation to Jerry Schmidt, dated Dec. 26, 1993. [1] = not on MBNF.

FISH
Colorado River cutthroat trout
flannelmouth sucker[1]
Colorado squawfish[1]
roundtail chub[1]
plains topminnow[1]

AMPHIBIANS
tiger salamander
boreal toad
leopard frog
wood frog

MAMMALS
pygmy shrew
dwarf shrew
fringe-tailed myotis
spotted bat[1]
Townsend's big-eared bat
red squirrel[1]
beaver
red-backed vole
long-tailes vole
Preble's jumping mouse[1]
western jumping mouse
swift fox[1]
black bear
ring-tail
pine marten
fisher[1]
wolverine[1]
mountain lion
lynx[1]

REPTILES
plains milk snake[1]

BIRDS
common loon
American bittern
white-faced ibis
Harlequin duck
osprey
bald eagle
northern goshawk
ferruginous hawk
merlin
Lewis' woodpecker
peregrine falcon
Columbian sharp-tailed grouse
western snowy plover[1]
mountain plover
upland sandpiper
yellow-billed cuckoo
long-billed curlew
black tern
flammulated owl
burrowing owl
boreal owl
black swift
northern 3-toed woodpecker
black-backed woodpecker[1]
olive-sided flycatcher
willow flycatcher
purple martin
pygmy nuthatch
brown creeper
golden-crowned kinglet
ruby-crowned kinglet
loggerhead shrike
warbling vireo
yellow warbler
fox sparrow
Lincoln's sparrow

Not all species have status on all lists. For example, some R-2 sensitiive species are not on the USFWS former candidate (2 or 3) list and vice versa, and Federally listed species are not on the R-2 Sensitive list. Data base information is current through May, 1994, from the Wyoming Game and Fish Department and the Wyoming Natural Diversity Database, The Nature Coservancy, Laramie, WY.

TECS SPECIES ABSTRACTS

Species abstracts are presented for Threatened, Endangered, Sensitive and (former) Candidate (C2) species known or likely to occur on the MBNF. Abstracts are not included for species of historic occurrence (Table AP8.2) or species very unlikely to occur.

Information for these abstracts was compiled mainly from Biological Evaluations (BE's) prepared by wildlife biologists Jerry Mastel for Brush Creek District-Cedar Timber Sale (Mastel 1994) and Joel Harper for Laramie District-White Swan-Holmes Timber Sale (Harper 1994). Fish and amphibian abstracts were prepared by Clay Speas and Greg Eaglin (fisheries biologists). Other staff reports were used where pertinent. A review of the status of information on northen goshawks was prepared (Haas 1993). Hank Henry, Greg Hayward, John Squires and Mike Young of the Rocky Mountain Forest and Range Experiment Station in Laramie provided current information on goshawks and pine marten via personal communication. Information from global and state species abstracts from the Nature Conservancy Fine Filter Report (Mills 1995) was used for broad-scale distribution and some habitat information.

There is a considerable body of information on bird-habitat relationships directly from research done on the Medicine Bow National Forest (Appendix 1). Current research on northern goshawks and pine marten is in progress at the Rocky Mountain Station in Laramie (papers by Squires, Henry, Ruggiero, and Raphael in Appendix 1). Past work has been done cooperatively by the Zoology and Range Science Departments at the University of Wyoming, the Wyoming Cooperative Research Unit and the Wyoming Game and Fish Department on many species (Buskirk, Keller, Anderson, Finch, Kreuger in Appendix 1). A population study on black bears is in progress (Grogan 1995). The information contained in this Biological Diversity Technical Report, especially the Bibliography of Scientific Studies in Appendix 1, should assist the effort to synthesize this information and make it useful to planning and management. Additional synthesis and evaluation of literature on many local studies (Cataloged in Appendix 1) needs to be done.

Species are presented by common name in the order listed below. Codes for species status with the Wyoming Natural Diversity Database are: G= global status; S= state status; 1 = critically imperiled because of extreme rarity; 2= imperiled because of rarity; 3 = rare or uncommon; 4 = apparantly secure; 5 = demonstrably secure; ? = uncertanity; A = accidental; For migratory birds: B = breeding status; N = non-breeding status; SZN = species not of concern; during migration or wintering periods. Examples: G5/S2 G5/S4B,SZN

Order of Species Abstracts Pages 8-20 through 8-73

Plants

autumn willow
clustered lady's slipper
Colorado tansy aster
Laramie columbine
Weber's ipomopsis

Animals

Fish
Colorado River cutthroat trout

Amphibians
western boreal toad
wood frog

Reptiles
pale milk snake
eastern short horned lizard
northern leopard frog
tiger salamander

Mammals

dwarf shrew
fringe-tailed myotis
long-eared myotis
long-legged myotis
small-footed myotis
Townsend's big-eared bat
pygmy shrew
marten

Birds

American bittern
northern 3-toed woodpecker
Baird's sparrow
bald eagle
black swift
black tern
boreal owl
burrowing owl
Columbian sharp-tailed grouse
common loon
ferruginous hawk
flammulated owl
fox sparrow
golden-crowned kinglet
Lewis' woodpecker
loggerhead shrike
long-billed curlew
merline
mountain plover
olive-sided flyatcher
osprey
peregrine falcon
purple martin
pycmy nuthatch
sandhill crane
upland sandpiper
white-faced ibis
northern goshawk

AUTUMN WILLOW

Salicaceae — *Salix serissima*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S2

Management Considerations:

Maintenence of good riparian condition and vigorous willow stands.

Distribution:

The main range of this species is Alberta to Newfoundland south to Minnesota and New York. It is disjunct in the Black Hills in South Dakota, the Laramie Range of Wyoming and the Long's Peak area in Colorado.

Occurrence on the Medicine Bow National Forest:

One collection in Crow Creek south of Happy Jack Road in a wet willow-sedge area.

Habitat:

It is found in montane riparian areas, associated with other species of willows.

Ecology:

It produces fruits later than most willows (July-September).

CLUSTERED LADY'S SLIPPER

Orchidaceae — *Cypripedium fasciculatum*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S2

Management Considerations:

Because this species is found in moist, shaded old forests, it is likely to be impacted by timber harvest. Surveys are needed since existing records are from scattered areas.

Distribution:

The species is distributed from southern British Columbia to California, Montana and Colorado. In Wyoming it is known only from the Sierra Madre and Medicine Bow Mountains.

Occurrence on the Medicine Bow National Forest:

This species has been collected in the Sierra Madre Mountains near Billie Creek, Lost Creek Campground, and near Dead Horse Park. It is known from the Fox Park area, near the Brush Creek Ranger Station, Barrett Ridge, and from the University Science Camp area in the Medicine Bow Mountains.

Habitat:

Clustered lady's-slippers are found in dry to moist open conifer forests at middle elevations ranging from 7,900 to 9,800 feet. They occur in duff in old spruce-fir or lodgepole pine forests and along shaded streams.

Ecology:

This terrestrial orchid is an extremely specialized perennial herb, intricately specialized in relation to its environment, including its pollinators. To germinate and grow, young plants must form an intimate partnership (symbiosis) with fungi in and around their roots, enabling them to take food from decaying material in the soil.

COLORADO TANSY ASTER

Asteraceae — *Machaeranthera coloradoensis*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G2?/S2

Management Considerations:

The species occurs on isolated sedimentary rock outcrops. No special management considerations are known.

Distribution:

This species is endemic to south-central Wyoming and western Colorado. There are only three Wyoming occurrences, all of which are on the Medicine Bow National Forest. Only one of these is a recent collection.

Occurrence on the Medicine Bow National Forest:

The species occurs on Hayden District in Jerry Park and Big Creek Park, and has been reported from the base of Sheep Mountain.

Habitat:

The habitat for this species is gravelly places in mountain parks, dry tundra, and on sandstone/limestone outcrops (Fertig 1994b).

LARAMIE COLUMBINE

Ranunculaceae — *Aquilegia laramiensis*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	formerly C2
Wyoming Natural Diversity Database:	G2/S2

Management Considerations:

No special management considerations are known.

Distribution:

The species is endemic to the Laramie Mountains and is known only from Albany and Converse Counties.

Occurrence on the Medicine Bow National Forest:

It occurs in small dispersed populations in rock crevices of Canyons in the vicinity of Laramie Peak. This includes the Ashenfelder Basin, Fall Creek, and Friend Park from about 6400 to 8000 feet.

Habitat:

Shaded rock crevices.

WEBER'S IPOMOPSIS

Polemoniaceae — *Ipomopsis aggregata spp. weberi*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5T2?Q/S1

Management Considerations:

Herbicide spraying of sagebrush occurred on state land adjacent to known populations of Weber's ipomopsis. The effect of herbicide spraying is unknown, but presumably would eliminate this species, at least temporarily.

Taxonomy:

This is a subspecies of a taxonomically complex genus.

Distribution:

The range is from northern Idaho to Northern Colorado.

Occurrence on the Medicine Bow National Forest:

It is known only from one area north of Battle Mountain near the Battle Mountain highway.

Habitat:

The habitat is described as openings in coniferous forest and scrub oak woodlands in the literature. In the southern Sierra Madre Mountains, it grows in gaps in sagebrush shrublands on quaternary alluvium and sedimentary rocks. Suitable habitat appears to be mostly on private lands adjacent to the National Forest.

ANIMALS

Fish

COLORADO RIVER CUTTHROAT TROUT

Salmonidae *Oncorhynchus clarki pleuriticus*

Status:

USDI Fish and Wildlife Service:	formerly C2
USDA Forest Service Region 2:	sensitive
Wyoming Natural Diversity Database:	G4/S2

Management Considerations:

Some of the current CRCT habitat has been altered by man's activities. Changes are due to four primary activities: 1) livestock grazing, 2) logging and associated road construction, 3) water diversions, and 4) mining. Fire suppression has also affected CRCT habitat as subalpine fir succeeds aspen stands within cutthroat watersheds thus decreasing the abundance and diversity of aspen. Aspen availablity influences numbers and distribution of beaver dams which provide important pool habitat for CRCT. A discussion of the effects of current and past land management activities on CRCT populations on the MBNF is in Speas et al. (1994).

Introduction of brook trout and other non-native species is believed to be the largest single factor leading to the reduced numbers and distribution of CRCT on the Medicine Bow National Forest. Some remaining populations of CRCT have been protected from further brook trout invasions by the construction of barriers. Exceptions to this include the headwaters of the Roaring Fork of the Little Snake. Forest Service and Wyoming Game and Fish personnel have scheduled the construction of a barrier on the Roaring Fork in 1995.

Protection from barriers may be short-term because barriers are susceptible to damage from high flows. Illegal transplants of non-native fish are a persistent threat to genetic integrity of Colorado Cutthroat trout populations. For example, the lower portion of the North Fork Little

Snake River was thought to contain an allopatric population of Colorado River cutthroat trout that was protected by a human-made barrier constructed in 1977. Several age classes of brook trout were discovered in 1995, apparantly the result of a transplant by anglers (M. Young personal communication).

Young (1995) and others have suggested three tactics for ensuring persistent populations of native cutthroat:

> Survey streams within the historical range to document CRCT populations and identify those which are unique
>
> Reestablish probable metapopulations that have been disrupted by man's activities;
>
> Protect and expand populations within their historical range. Include well-distributed refugia, habitat for all life stages, and movement corridors.

All three of these principles are part of a CRCT conservation strategy completed in 1994 (Speas et al. 1994). Both habitat and population would be monitored on a regular basis to determine their trend and to document changes in their status and quality. Fragmented populations in the North Fork Little Snake and the west branch of the Little Snake would be reunited into one continuous population. CRCT would also be re-introduced in Muddy Creek drainage (a tributary to the Little Snake River) on Bureau of Land Management Lands.

Discussion of effects of sediment loads on Colorado River cutthroat trout and other species can be found in Alexander et al. 1985; Eaglin 1991; Griffith 1988; Hipple 1986; Leaf 1970; Schmal 1986; Troendle and King 1980, 1987; Wesche et al. 1977; and Wilcox 1989. Most of these studies were done on the MBNF.

Taxonomy:

The Colorado River Cutthroat Trout (CRCT) is the only trout endemic to the Green River drainage of Wyoming. The subspecies was first described by Cope (1871) when he surveyed Wyoming fish and reptiles. Descriptions of scale counts, spotting, and coloration were added by Jordon (1891). The first complete description of the subspecies based on morphological measures (variations in body morphology, spotting patterns, and meristic characteristics) was done in 1976 by Behnke and Zarn. Chromosome karyotyping, protein electrophoresis, and more recently, the use of mitochondrial DNA, have been used to examine taxonomic relationships among cutthroat subspecies. Others have noted increased

discrimination among populations with these techniques as compared to that provided by morphology (Shiozawa et al. 1993, 1994).

Thirty-two streams on the Medicine Bow National Forest contain good representatives of the subspecies based on meristic characteristics and/or electrophoretic analysis (Table 8.8). Good representatives have been defined by Binns (1977) as those stocks that have a purity rating of "C" or better. High purity populations ("A") are restricted to areas which are physically or chemically isolated. For example, Ted Creek and upper North Fork Little Snake River have separate populations because the CRCT in those streams have been isolated by Cheyenne Water Project Stage I diversion structures. "A" purity populations in the headwaters of Solomon Creek were isolated in the early 1980s by Stage II of the Cheyenne Water Project. Copper effluent from the Ferris-Haggerty Mine creates a chemical barrier in Haggerty Creek. High purity populations exist in Alisha Creek, Bachelor Creek, and Green Creek as a result of this chemical barrier.

Description:

External meristic characteristics of the fish include large, round, black spots that are concentrated posteriorly and mostly along the lateral line. The spotting varies according to geographical location, with the fish in the Little Snake River drainage having somewhat larger spots than fish in the Green River and the Blacks Fork River (Binns 1977). Scales are small, with 43 or more above the lateral line. Coloration is well developed, particularly in spawning males, and includes a well developed jaw slash and ventral colors that are typically bright orange in the Little Snake River fish. Overall body color is bronze gold to silver with a distinct black margin on the adipose fin.

Distribution:

The historic range of the subspecies extended from the headwaters of the Colorado River downstream to the Dirty Devil River of Arizona on the east (Behnke and Zarn 1976). During the past 100 years, the subspecies has been adversely affected by hybridization and competition with introduced trout, as well as the development of land and water resources within the Green River Basin (Binns 1977). Populations have been drastically reduced; currently, CRCT occupy about one percent of their historic range (Young 1995).

In Wyoming four widely separated enclaves of CRCT have been identified: 1) the Green River enclave (west side tributaries), 2) the Blacks Fork enclave, 3) the North Fork Little Snake enclave, and 4) the Big Sandstone enclave. An enclave is defined as a set of distinct populations in a given geographic area. The Little Snake River and Big Sandstone

enclaves have been combined to form the Little Snake River enclave (Oberholtzer 1990).

Within the Little Snake River drainage, all current populations are known to reside in or immediately adjacent to the Medicine Bow National Forest. Currently, in 51 miles of stream in 29 eighth level watersheds, allopatric populations of CRCT exist within their historic ranges (Figure 8.1). Five additional populations have been established by the Wyoming Game and Fish Department in the North Platte River drainage. North Platte River populations were established from hatchery stocks taken from the Blacks Fork drainage in Wyoming.

Recently the USDA Forest Service initiated efforts to identify the state of science and management strategies for each subspecies of inland cutthroat trout (Young 1995; Schmal in preparation). A total of 238 populations of CRCT were identified in a tri-state area: 111 in Colorado, 106 in Wyoming, and 21 in Utah. However, recent extinctions were documented throughout their historic ranges (Schmal et. al. 1995). Of the 238 populations, only 20 were found to be genetically pure, free from non native trout, and protected by barriers. Of the 20, eight populations (42 percent) are located on the Medicine Bow National Forest. Under existing conservation strategies an additional four populations will be genetically pure, free from non native trout, and physically isolated by the year 1996 (Speas et. al. 1994).

In 1977, Binns reported that the North Fork Little Snake River hosted the largest and least fragmented population of CRCT known to exist in Wyoming. However, construction of Cheyenne Water Project Stage II diversion structures has fragmented streams in the West Branch and North Fork Little Snake River. The diversion structures restrict movement between formerly connected populations, leaving small isolated populations that are more vulnerable to extinction. The remainder of the known populations on the Forest are reproductively isolated and have limited population size. Isolation is typically the result of a natural or manmade barrier downstream, below which allopatric populations of brook trout exist.

Table 8.8 Colorado River cutthroat trout genetic purity characteristics for the Little Snake River Enclave, WY. (1994)

STREAM	STOCK PURITY	STATUS	DENSITY	REMARKS
Alisha Creek	A	2	C	
Bachelor Creek	A	2	S	
Beaver Creek	A	3	R	
Deadline Creek	---	3	S	
Deadman Creek	C	1	A	Some evidence of rainbow trout contamination.
Deep Creek	C			Evidence of rainbow trout contamination.
Deep Creek, East Branch	A	3	S	
Deep Creek, West Branch	---	3	S	
Dirtyman Creek	B+	1	A	A few individuals exhibit rainbow trout charactersistics.
Elk Creek	B	3	S	Some evidence of rainbow trout contamination.
Green Creek	A	2	C	
Green Timber Creek	B	2	C	Evidence of rainbow and/or yellowstone cutthroat trout contamination.
Haggerty Creek	___	2	S	No sampling has been conducted.
Harrison Creek	C	1	A	Evidence of rainbow and yellowstone cutthroat trout contamination.
Haskins Creek, West Branch	A	3	R	Purity rating is based on analysis of one fish.
Hatch Creek	B	2	C	Some evidence of rainbow trout contamination.

Table 8.8 continued.

STREAM	STOCK PURITY	STATUS	DENSITY	REMARKS
Hell Canyon Creek	B	2	S	Some evidence of rainbow trout contamination.
Mill Creek, (Right Branch)	___	3	S	No sampling has been conducted.
Mill Creek	B	1	C	Evidence of rainbow trout and Yellowstone cutthroat trout contamination.
Mill Creek, South Fork	___	3	S	No purity analysis conducted.
Rabbit Creek	A	3	S	
Roaring Fork	A	1	A	Electrophoretic analysis, conducted in 1993, found fish to be pure with a high level of genetic divergence.
Rose Creek	B+	1	A	External characteristics only were examined.
Skull Creek	B	3	S	Evidence of rainbow trout and Yellowstone cutthroat contamination.
Little Snake River, North Fork	D-A	1	A	A purity gradient exists in the North Fork, with fish from lower area near the fish barrier rating as a "D", and those upstream near the Stage I Diversion rating as a "B". Fish above the Stage I Diversion are considered "A" purity.

Table 8.8 continued.

STREAM	STOCK PURITY	STATUS	DENSITY	REMARKS
Solomon Creek	A	1	A	Electrophoretic analysis, conducted in 1993, determined these fish to be pure *O. pleuriticus*. This is an up-grade from the "B+" purity level using meristic analysis.
Standard Creek	C	2	C	Obvious contamination with rainbow trout.
Ted Creek	A	2	S	Electrophoretic analysis conducted in 1993 confirmed purity level.
Third Creek	C	2	S	Obvious contamination with rainbow trout.
West Branch (NFLS)	B	3	S	Some contamination with rainbow trout.

Stock purity

Symbol	Meaning
A	Pure.
B	Essentially pure, with trace contamination.
C	Good representatives of *O. pleuriticus* stock with some contamination by other trout species.
D	Representative of *O. pleuriticus* stock, but meristic and/or external characters show definite signs of hybridization.

Population Status

Symbol	Meaning
1	Well established in present habitat. Population appears relatively stable under existing conditions.
2	Adequately established in present habitat, but populations may be unstable due to fluctuating habitat conditions.
3	Precarious. Low population levels either due to poor habitat conditions or the presence of brook trout.

Table 8.8 continued.

Density

Symbol	Meaning
A	Abundant
C	Common (moderate population density)
S	Sparse (light population density)
R	Rare (infrequent occurrence)

Habitat:

The general habitat requirements of various life stages of Colorado River cutthroat trout are discussed by Young (1995). Habitat requirements for cutthroat trout in Wyoming are in Binns (1977). Historically CRCT existed in a wide range of habitats, but are currently relegated to headwater streams. These streams are generally over 8000 feet above mean sea level and characterized by cold, clean, well oxygenated water with pH ranging from six to nine. Stream gradient generally exceeds four percent with a substrate composition of cobble, boulder, and gravel and a good balance of pools and riffles. Pools formed by beaver dams, large woody debris, or other structural elements are the habitat type most utilized by CRCT, especially the larger fish (Herger, 1993). In late summer, as living space declines, pools become increasingly important for fish of all sizes. Optimal lacustrine habitat is characterized by clear, cold, deep lakes that are typically oligotrophic.

Young fish prefer areas with low velocities or shelter from higher velocities (Bozek and Rahel 1991). These sheltered areas were most often associated with rootwads and boulders. However, fry only occurred in areas in proximity to adequate spawning habitat.

Adult habitat on the Medicine Bow National Forest primarily seems to be pools formed by large wood or boulders. The depth of pool influences the density of CRCT (Herger 1993). Over 40 percent of the occupied habitats in the North Fork Little Snake river were created by large wood in the channel, even though they only represented ten percent of the pool habitat available; pools created by meanders were utilized less by the adult fish (Young, 1995). Within the North Fork Little Snake River, Jesperson (1981) found 78 percent of the variation of CRCT biomass to be attributable to the presence of spawning habitat, cover, and the velocity of water in the riffles. Spawning habitat was the single greatest factor affecting CRCT biomass. Spawning substrates in the North Fork Little Snake River limited the population (Jesperson 1979).

Fish occupy different areas seasonally. Jesperson (1979, 1980) found different age classes in different portions of the North Fork Little Snake River which he believed to be a result of fish movement in the drainage. Also, Jesperson (1981) documented fish movement downstream during late summer and early fall. Young (1995) observed fish moving both up and downstream as much as 1,000 meters from June to mid-August. Typically, the fish left the tributaries following spawning and moved both upstream and downstream from the tributary mouths. Movement within the drainage continued throughout late summer and early fall, but at a reduced rate.

Life History Characteristics

Spawning takes place from late spring to early summer when peak spring flows begin to diminish (Quinlan 1980; Jesperson 1981). Spawning is initiated when water temperatures reach approximately 7°C (Benke and Zarn 1976). Redds are generally located in areas where velocity, depth, substrate, and bottom configuration allow water flow through the substrate (Young 1989). Redds are generally small, containing clean gravel and located at a water depths of 0.2 to 1.0 feet where velocities average 1.0 to 2.1 feet per second (Conder and Jesperson 1986; Quinlan 1980). Jesperson (1981) documented spawning in intermittent streams with unsuitable adult habitat. In small headwater streams, sexually mature fish may only be five to eight inches in length and spawn only 100-200 eggs. CRCT generally reach sexual maturity between two and four years of age (Binns 1977).

Size:

Historically, CRCT are believed to have reached large sizes in the Colorado River Basin. Unverified reports of fish as large as 20 pounds or more exist (Behnke 1992). Today, the remaining populations of CRCT are located in small headwater streams, and individuals seldom exceed 12 inches in length. However, when these fish are removed from high altitude environments and placed in lower elevation ponds, they have been documented to exceed 15 inches in length over two years (Fowden personal communicatio). Larger fish have been taken from lake populations in Colorado, but no lake populations of CRCT currently exist in the Little Snake River drainage.

Range Contraction:

Colorado River cutthroat trout have evolved in sympatry with other native species in the Little Snake River drainage including mottled sculpin and possibly flannelmouth suckers, bluehead suckers, mountain sucker, speckled dace, roundtail chub and mountain whitefish and even possibly Colorado River squawfish (Young 1995).

Widespread stocking of non-native fishes in the Little Snake River began in the early 1930s with major effects on distribution of CRCT in the Little Snake River drainage. Non-native salmonids have affected CRCT through competition, eventually eliminating CRCT from the occupied waters. This is especially true at lower elevations and in low gradient streams within the drainage (Young 1995).

Data compiled from Wyoming Game and Fish survey reports, Medicine Bow National Forest survey reports, and personal observation from biologists involved in CRCT management within the Little Snake River drainage over the past 20 years testify to the deleterious effect stocking of non-native fish species has had on CRCT populations. In the 1950s,

allopatric populations of CRCT occurred in approximately 73 miles in 32 streams (2nd order and larger) in the drainage. By 1994, the total miles with allopatric populations dropped to approximately 51 miles in 27 streams. This represents a 30 percent reduction in stream miles occupied by CRCT over 40 years. In the Douglas Creek tributary to the Big Sandstone Creek alone, brook trout replaced CRCT from 1982 to 1986 (Oberholtzer 1990). The only remaining CRCT known to exist in Big Sandstone Creek drainage occur in the upper reaches of Deep and Mill Creeks. Both of these streams have man-made barriers to preclude any further invasion by brook trout.

Biotic Interactions:

Hybridization is the primary cause of the loss of pure forms of native trout in the western states (Behnke 1992). Interbreeding of native CRCT with non-native salmonids is threatening the existence of CRCT in stocks in the Little Snake River drainage. Forty-four percent of the Medicine Bow National Forest streams contain CRCT exhibiting some level of hybridization with other salmonids. Hybridization is believed to have occurred with both Yellowstone cutthroat trout and rainbow trout.

CRCT are typically generalists or opportunistic feeders (Binns 1977). In Trappers Lake, Colorado, Colborn (1966) found the primary components of Colorado River cutthroat trout summer diet to be amphipods, other plankton, dipterans, and terrestrial hymenopterans . In small headwater streams, they usually consume a wide range of aquatic and, to a lesser extent, terrestrial invertebrates. Larger fish occasionally feed on fish and become more piscivorous as their size increases (Colborn, 1966). In general, stream-dwelling trout are less piscivorous than trout found in lake environments (Behnke 1992).

Gyrodactylis elegans, a monogenetic fluke, has been discovered to affect CRCT in the North Fork Little Snake River. This fluke inhabits the gill region of the fish. In extreme cases, it has resulted in fish mortality in both lake and hatchery settings in Wyoming (Doug Mitchum, pers. comm.). Infection by the fluke in the North Fork fish does not appear to be a significant problem at the present time.

Whirling disease has been found in trout in the North Platte River in North Park. This is not expected to be a serious problem in trout populations on the MBNF because the secondary host (*Tubifex*) is not abundant (Mitchum. personal communication).

WESTERN BOREAL TOAD

Bufonidae *Bufo boreas boreas*

Status:

USDI Fish and Wildlife Service: formerly C2

Recently, the USDI Fish and Wildlife Service was petitioned by the BioDiversity Legal Foundation to list the southern Rocky Mountain population of boreal toad in Wyoming and Colorado. At present, the Service has recommended the status be changed from C2 to C1 status.

USDA Forest Service: sensitive

Wyoming Natural Diversity Database: G5/S1

Management Considerations:

Causes of the decline in toad numbers are not known. Potential reasons include habitat alteration resulting from timber management, grazing, recreation activities and water storage projects, disease, and pH changes from acid rain. No single factor can be identified as the primary cause for the decline (Nesler 1994). It is believed that any forest management activity which negatively affects wetlands or ponds will have an adverse effect on toad populations. Another possible cause for the decline is acid deposition, but this is not considered significant enough in scope to cause widespread decline in boreal toad populations (Corn and Vertucci 1992). Widespread pesticide application to control forest insects and the use of chemicals like rotenone and antimycin (commonly used in fisheries reclamation projects) have also been considered, but no information exists to support or refute their hypothesized adverse effects on boreal toad populations (Nesler 1994).

Stress-induced infections of a highly contagious bacterial pathogen, *Aeromonas*, which causes red legged disease amphibians, has been suggested by Nesler (1994). This hypothesis was formulated by the work of Cary (1993) as follows: 1) some environmental or other factors that cause the toad to experience sublethal stress, 2) stress causes suppression of the toads immune system, and 3) immunosuppression coupled with the effects of cold body temperature of ectothermic animal ability to fight off bacterial disease leads to widespread infection and mortality. The specific causes of the stress are unknown. However, increased exposure to ultra-violet light resulting from atmospheric changes may be a contributing factor.

Description:

Boreal toad adults have dark warty skin, oval paratoid glands, and a white vertical stripe down their backs; they lack a cranial crest (Nesler 1994). Adults are approximately five inches long from snout to toes. The length of the toad from snout to vent is generally less than three and a half inches (Hammerson 1986). Eggs are usually black, round in shape, and form long gelatinous strings. Tadpoles are jet black and are commonly found in aggregations. Recently metamorphosed young toads (toadlets) exhibit adult characteristics, but have reddish-orange coloration on their toes.

Distribution:

The boreal toad historically ranged from Alaska to northern New Mexico in the Rocky Mountains and west to the Pacific Coast. In Wyoming, the toad was found throughout the central and western mountains; however, it has never been sighted in the Big Horn Mountains (Baxter and Stone, 1980). As of 1980, the boreal toad was considered common in the State of Wyoming (Baxter and Stone 1980). Baxter and Stone (1985) reported that the toad's historic range encompasses the entire Sierra Madre Mountains, the Snowy Range, and the Laramie Mountains. Toads have been captured in 34 watersheds on the Medicine Bow National Forest (Figure 8.2).

Beginning in the 1970s, scientists noticed a decline in toad numbers in many areas of Wyoming (Garber 1994). Recently, attempts have been made to document the decline of the boreal toad in Colorado and Wyoming. Corn et al. (1989) found toads to be absent from 94 percent (10 of 59 sites) of the historic ranges in Albany and Carbon Counties on the Medicine Bow National Forest. From 1990 to 1994, Forest Service and Nature Conservancy personnel conducted additional surveys of the toad's historically occupied habitat. In over 500 hours of searching, only seven toads were discovered in three watersheds (Figure 8.2). The largest number of individuals was sighted in the Little Laramie River drainage on the Laramie Ranger District. Surveys have been done by Garber (1992; 1995).

Life History and Habitat Requirements:

The known elevational range for the toad is from 7,000 feet to 12,900 feet. Distribution is restricted to areas with suitable breeding habitat in spruce-fir forests and alpine meadows. However, toads discovered on the Medicine Bow National Forest were most often associated with beaver ponds or side channel habitats. The Nature Conservancy considers all riparian areas within the requisite elevation range as being suitable habitat.

Breeding habitat includes marshes, ponds, bogs and wet meadows with sunny exposure and calm, shallow water. Adult toads have been known

to move several miles from their breeding ponds while juveniles remain within them.

Toads generally go into hibernation during late August and early September and emerge in May (Hammerson 1986). Upon emerging from hibernation, with the melt of winter snowpack toads begin breeding and lay eggs in late May and early June (Nessler 1994). In the Snowy Range above 10,000 feet, the toad historically breeds in shallow water along the north shoreline of small lakes (Baxter and Stone 1980). The eggs are laid in long gelatinous strings. The timing of the egg hatch is temperature dependent and can take up to 75 days in higher elevations (Nessler, 1994). Campbell (1970) documented tadpoles overwintering beneath the ice cover, but this has not been documented in the Snowy Range (Baxter and Stone 1980; Garber 1994). The metamorphosis of the tadpoles into toadlets usually occurs in late July to mid-August (Campbell 1972). At elevations greater than 10,000 feet, Baxter (1952) indicates that toads usually fail to transform in the short summer season and colder temperatures. He hypothesized that higher elevation populations were being maintained by toad migration from lower to higher elevations.

Food Requirements:

Insects and ants make up a large portion of the toad's diet.

WOOD FROG

Ranidae *Rana sylvatica*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S2

Management Considerations:

Fish introductions into fishless lakes and ponds. Removal of trees from the edges of ponds and kettleholes. Large areas of kettleholes on the Brush Creek District were affected by clearcuts of the 1950s-1970s.

Distribution:

Throughout Canada, Alaska, eastern U.S., Idaho. Disjunct populations in the Rocky Mountains.

Occurrence on the Medicine Bow National Forest:

Laramie District - Heidrich Creek, Bear Creek, Woods Creek, Evans Creek, Fox Creek, spur ponds, railroad ponds. Strain Creek, Fallen Pines timber sale area, Little Laramie River.

Brush Creek District - Long Lake, South Brush Creek, Turpin Reservoir Ponds, Stillwater Park. See Garber 1992, 1995; Orde 1982; Orde and Bartlett 1990; and Figure 8.3.

Habitat:

Kettleholes without fish populations on the Medicine Bow National Forest.

NORTHERN LEOPARD FROG

Ranidae — *Rana pipiens*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S1

Management Considerations:

No special considerations if riparian areas are in good condition and beaver ponds available.

Distribution:

Throughout Canada, Alaska, eastern U.S., Idaho. Disjunct populations in the Rocky Mountains.

Occurrence on the Medicine Bow National Forest:

Sherman Mountains (beaver ponds), Lake Owen, Foxpark area

Habitat:

Beaver ponds.

TIGER SALAMANDER

Ambystomidae — *Ambystoma tigrinum*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S5

Management Considerations:

No special considerations if riparian areas are in good condition.

Distribution:

Throughout most of North America.

Occurrence on the Medicine Bow National Forest:

Found in all mountain ranges, up to about 10,000 feet.

Habitat:

Nearly any habitat with substrate for burrowing, near water.

REPTILES

PALE MILK SNAKE

Colubridae — *Lampropeltis triangulum*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S4

Management Considerations:

No management considerations are known.

Distribution:

This species is found from southern Maine to Montana and south to South America.

Occurrence on the Medicine Bow National Forest:

Pale milk snakes occur in the Laramie Mountains.

Habitat:

Diverse habitats from plains to forests. Usually resides underneath rocks or logs.

EASTERN SHORT-HORNED LIZARD

("horney toad")

Iguanidae — *Phrynosoma douglassii brevirostra*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	none
Wyoming Natural Diversity Database:	G5/S4

Management Considerations:

No management considerations are known.

Distribution:

This species is found in the Northern Great Plains and Rocky Mountains.

Occurrence on the Medicine Bow National Forest:

The species occurs in the Laramie Mountains.

Habitat:

Dry areas, grassy, rocky or under forests.

MAMMALS

DWARF SHREW

Soricidae *Sorex nanus*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S3

Management Considerations:

There are no known management considerations.

Distribution:

The range of the dwarf shrew is limited to eastern Utah, Wyoming, and western Colorado. Fossil records suggest that dwarf shrews inhabited rubble slopes and coniferous forests in Kansas and southern New Mexico when glaciers covered much of the Rocky Mountains. Its distribution evidently shrank with the recession of glaciers.

Occurrence on the Medicine Bow National Forest:

Dwarf shrews have been found near Centennial, WY.

Habitat:

This shrew typically occurs as isolated relict populations in alpine and subalpine zones, in association with rock slides and talus slopes (Brown 1967; Clark and Stromberg 1987). It is less commonly found at lower elevations in sedge marshes, alkaline sage flats, shortgrass prairie, and pinyon-juniper.

Ecology:

Dwarf shrews nest in burrows and feed on carrion of small mammals, spiders, and soft-bodied insects.

PYGMY SHREW

Soricidae *Sorex hoyi*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S2S3

Management Considerations:

Habitat aound kettleholes has been altered by past clear-cutting.

Distribution:

Pygmy shrews range from the taiga of Alaska, across Canada and the northern United States, and in scattered populations in the Rocky Mountains and southward in the Appalachian Mountains to North Carolina. The populations in the Rocky Mountains start at the Medicine Bow Mountains in Wyoming and extend south to central Colorado. These disjunct populations are isolated by hundreds of kilometers from any other populations to the northwest. The isolation of the Rocky Mountain populations from Northwest pygmy shrews is attributed to the effects of recent glaciation. As the glaciers retreated and the climate warmed, pygmy shrews persisted in the cool, wet mountains.

Occurrence on the Medicine Bow National Forest:

As of 1987 pygmy shrews are known in Wyoming only from eight specimens, seven of which were taken from Trails Divide Pond, which is on the east side of the Medicine Bow Mountains (Clark and Stromberg 1987). This population occurs in the only latilong in the state with current breeding records for pygmy shrews (Oakleaf et al. 1992).

Habitat:

Pygmy shrews in Wyoming prefer sphagnum moss on edges of small ponds in spruce-fir forests, moist meadows, bogs, and other wet areas at high elevations, mostly above 9,000 feet.

Ecology:

They nest in old, decaying logs and in the roots of tree stumps. Pygmy shrews feed on a variety of arthropods, worms, and insects. Feeding areas consist of interspersed wet and dry sites to assure an adequate prey base.

FRINGE-TAILED MYOTIS

Vespertilionidae *Myotis thysanodes*

Status:

U.S.. Fish & Wildlife Service:	formerly C2
U.S. Forest Service:	none
Wyoming Natural Diversity Database:	G5/S4

Management Considerations:

This species is extremely susceptible to disturbances during hibernation.

Distribution:

This rare bat occurs from British Columbia through the western states to southern Mexico. Fringe-tailed myotis skirt Wyoming for the most part to the west and south, yet occur as isolated populations in the Black Hills and south to Laramie (Clark and Stromberg, 1987; Tuttle, 1984).

Occurrence on the Medicine Bow National Forest:

They have been reported in latitude-longitudes containing the Medicine Bow National Forest except for the Sierra Madre, but specific population data is lacking.

Habitat:

This bat species inhabits mid-elevation grasslands, deserts, and oak and pinyon woodlands, and is occasionally observed as high as spruce-fir habitats (Finch 1992). In Colorado, the fringed bat is reported to breed in caves and winter in pinyon-juniper and ponderosa pine habitats. It prefers caves, mines, and rock crevices for day and night roosting (USDA Forest Service 1981). Cave or cliff habitat is very limited on the MBNF. Forest.

Ecology:

Fringed-tailed myotis typically forage over watercourses for insects, but also feed on beetles. This species typically migrates, but is also known to hibernate in caves in the Black Hills. Pregnant females form large nurseries of up to several hundred individuals in buildings, crevices, or trees. Males are segregated and solitary during the maternity season. Longevity is up to 11 years.

LONG-EARED MYOTIS

Vespertilionidae *Myotis evotis*

Status:

U.S. Fish & Wildlife Service:	species at risk
U.S. Forest Service:	none
Wyoming Natual Diversity Database:	G5/S4

Management Considerations:

Forest and wetland habitats which support insect populations are important to this species.

Distribution:

This species ranges from central Mexico northward to British Columbia and eastward to the western edge of the Great Plains, including the western Dakotas and Nebraska.

Occurrence on the Medicine Bow National Forest:

It is found in all four Mountain areas of the Medicine Bow National Forest, but specific population data is lacking.

Habitat:

This species is found in coniferous forest. Ponderosa pine woodland is the most common habitat type, although this bats ranges south into pinon-juniper woodlands in Colorado (Tuttle 1981).

Ecology:

Reproduction of this species has not been studied in detail. Roosts are in trees (often behind loose bark), in sheds, cabins, abandoned mines, and similar sheltered areas. Females appear to form small breeding colonies of one to three dozen individuals. The long-eared myotis emerges after dark to forage, feeding near trees or over water. Primary food items are moths, flies, spiders, and beetles. Little is known of their hibernation or migration patterns in this area.

LONG-LEGGED MYOTIS

Vespertilionidae *Myotis volans*

Status:

U.S. Fish & Wildlife Service:	formerly C2
U.S. Forest Service:	none
Wyoming Natural Diversity Database:	G5/S4

Management Considerations:

This species is associated with forests and forested wetlands.

Distribution:

This species occurs throughout much of western North America, from central Mexico to extreme northwestern British Columbia and from the Pacific coast to the western margins of the Great Plains.

Occurrence on the Medicine Bow National Forest:

It is found in all four mountain areas of the MBNF, but specific population data are lacking.

Habitat:

The long-legged myotis occupies wooded areas in foothills, mountains, and high plateaus. Typical habitat is mountain or sub-alpine forest, ponderosa pine woodlands, canyon-juniper woodlands, and mountain shrub with willows or well-watered vegetation.

Ecology:

Bats roost by day in buildings, fissures in rocks, and beneath loose bark on trees, normally alone or in small groups. Night roosts are dark places like caves or mine shafts. Their hibernation or migration patterns are not well understood locally. Elsewhere, they are known to hibernate singly in mines or caves. This species feeds primarily on moths.

SMALL-FOOTED MYOTIS

Vespertilionidae *Myotis ciliolabrum*

Status:

U.S. Fish & Wildlife Service:	formerly C2
U.S. Forest Service:	none
Wyoming Natural Diversity Database:	G5/S4

Management Considerations:

None known.

Taxonomy:

Has also been known as *M. leibii* and *M. subulatus*.

Distribution:

This bat species is widespread in North America and is common in the western United States and extreme southern Canada.

Occurrence on the Medicine Bow National Forest:

It is found in all four mountain areas of the MBNF, but specific population data are lacking.

Habitat:

Despite the widespread occurrence of this species, very little is known of its habitat requirements, although it is known to be saxicolous (inhabiting rocky areas) and is more common at lower elevations.

Ecology:

Summer roosts are highly variable and include buildings, mines, beneath bark on trees, and a variety of other sites. Individuals are solitary and at least in Colorado, are year-round residents. In the winter, they are found in caves and mine shafts, either alone or in groups. The hoary bat has been documented to prey on this species. Small nursery colonies of 10 - 15 bats are occasionally found in caves, mines, or buildings. The most common litter size appears to be one young per year. They feed early in the evening on small flying insects, such as, flies or beetles.

TOWNSEND'S BIG-EARED BAT

Vespertilionidae — *Plecotus townsendii*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S3

Management Considerations:

There are no known management considerations.

Distribution:

This bat ranges throughout the western half of North America and south into central Mexico (Clark and Stromberg 1987). It is rare in Wyoming, but has been observed throughout the state. Its residency status is undetermined (Oakleaf et al. 1992).

Occurrence on the Medicine Bow National Forest:

It is believed present in all four Mountain areas of the Medicine Bow National Forest, but specific population data are lacking.

Habitat:

Habitats used include deciduous forests, dry coniferous forests, pinyon-juniper woodland, desert shrubland, and mountain foothills. Townsend's big-eared bat is a cave dweller for both day roosts and hibernation sites. It is frequently found in abandoned mines. There are no known caves or abandoned mines. It also commonly uses buildings, but only as night roosts.

MARTEN

Mustelidae — *Martes americana*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S3S4

Management Considerations:

Martens are furbearers, and about 300 animals are trapped in Wyoming each year (Crowe 1986). Nearly two dozen published studies on marten have been done on the Medicine Bow National Forest (See Appendix 1). Home ranges include structurally complex older forests. They utilize a variety of forest structural features during various parts of their life

history. Suggestions for monitoring marten on the MBNF are in Raphael (1987).

Distribution:

American martens, often called pine martens, range from Alaska, across Canada to the northeastern United States, and south along the major mountain ranges in the western United States. They inhabit the mountains of the southcentral, western, and northern parts of Wyoming from 8200-11,000 feet.

Occurrence on the Medicine Bow National Forest:

The Wyoming Game and Fish Department Wildlife Observation System Data Base contains about 20 marten observations in the two project area watersheds. Martens have also been observed by Brush Creek District personnel in the northwestern part of the Snowy Range. Studies by Buskirk, Henry, Corn, and Raphael have been done on specific marten populations and aspects of marten ecology which interact with specific habitat characteristics of old growth forests (Appendix 1).

Habitat:

They prefer late successional stands of mesic, conifer-dominated forest, preferably spruce-fir, but also occupy lodgepole pine, Douglas fir, and occasionally cottonwood riparian areas. They tend to avoid clearcuts and large openings (Henry personal communication).

Ecology:

Use of habitat is related to food availability, especially in winter when they often search interstitial dense log areas below snow for food. Rock outcrops are used in summer. Martens feed on small mammals, especially red-backed voles, red squirrels, some birds, insects, fruits, and berries. Dens are key habitat components, which may be at considerable height from the ground in a hollow tree (often an abandoned woodpecker hole) lined with grass, leaves, and mosses. Dens on the ground are usually associated with rock piles or hollow logs. Therefore, snags, large logs and rock outcrops are important habitat components for this species (Clark and Stromberg 1987; Finch 1992; Oakleaf et al. 1992; Martin and Barrett 1983). See Ruggiero et al. (1994) for a comprehensive discussion.

BIRDS

AMERICAN BITTERN

Ardeidae — *Botarus lentiginosus*

Status:

U.S. Fish & Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S3B, S4N

Management Considerations:

The Office of Migratory Bird Management (OMBM) (1982) listed the American bittern as a migratory species of management concern in 1982 and 1987 because of its patchy distribution and dependence on vulnerable wetland habitats. Maintenence of larger beaver ponds and kettlehole habitats is important to this species.

Distribution:

Bitterns inhabit fresh water or saltwater marshes, bogs, swamps, wet meadows, or wherever the vegetation is wet and tall. They are often associated with cattail patches.

Occurrence on the Medicine Bow National Forest:

They are found in all four mountain ranges of the Medicine Bow National Forest, but population information is lacking. Oakleaf et al. (1992) indicate there is circumstantial evidence of nesting for this part of Wyoming. This species is more likely to be found at lower elevations off NFS lands, but they are known from ponds in the Moerke Lake area and larger riparian areas associated with beaver pond complexes at lower elevations near the forest boundary.

Ecology:

Bitterns consume a variety of foods, including mollusks, spiders, crustaceans, fish, frogs, salamanders, snakes, lizards, terrestrial and aquatic insects, and a variety of small birds and mammals. Based on breeding bird surveys from 1966 to 1985, bittern populations have declined in the midwest and northeast but appear stable in the east and west. (Finch 1992). Sample sizes for Wyoming were insufficient for trend analysis. Brown and Dinsmore (1986) failed to record American bitterns in marshes less 11 ha in size.

BAIRD'S SPARROW

Emberizidae — *Ammodramus bairdii*

Status:

U.S. Fish & Wildlife Service:	formerly C2 at risk
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G3/S3B, S5N

Management Considerations:

No special considerations are known.

Distribution:

Baird's sparrows have a restricted breeding range occurring only in the northern Great Plains states of Montana, North Dakota, South Dakota, Alberta, Manitoba, and Saskatchewan (Finch 1992). They are suspected to nest in Wyoming (Oakleaf et. al. 1982).

Occurrence on the Medicine Bow National Forest:

The Laramie Mountains contain likely habitat. There is no information on populations of these birds on the Medicine Bow National Forest.

Habitat:

The species is restricted to grass prairie habitat and weedy fields.

Ecology:

Baird's sparrows are ground nesters in tall grass in prairie habitats. Breeding bird surveys indicated significant declines from 1966 to 1985 in population densities in five of the six states and over the entire continent. Trends were negative in the Rocky Mountains/Great Plains region, the Central region, and the U.S.

BALD EAGLE

Accipitridae — *Haliaeetus leucocephalus*

Status:

U.S. Fish and Wildlife Service:	threatened
U.S. Forest Service:	none
Wyoming Natural Diversity Database:	G4/S1B, S2N

Management Considerations:

Maintenance of snag habitat.

Distribution:

Nesting bald eagles are closely associated with lakes and large rivers in open areas, forests, and mountains (DeGraaf et al. 1991). Nests are

commonly found in large trees, mainly conifers and cottonwoods. Because eagles need large trees to support their large nests, they are often found in multi-storied, old growth stands with open canopies (Spahr et al. 1991).

Occurrence on the Medicine Bow National Forest:

Nesting bald eagles have been observed along the North Platte River eight to ten miles from National Forest System (NFS) lands. There are no known nest sites on NFS lands; however, these lands are within the range of a daily foraging area commonly used by bald eagles (Oakleaf et al. 1992, Medicine Bow National Forest FEIS, Brush Creek District records). It is possible that bald eagles nesting along the North Platte River may hunt prey or consume carrion on the Forest, especially big game carcasses on winter range areas. These areas are only considered marginal as foraging areas. It is also probable that bald eagles migrate through the area. The Wyoming Game and Fish Wildlife Observation System database contains 14 recorded observations (not nesting) of bald eagles from 1978 to present. Most of these observations occur during migration periods.

Wintering bald eagles have been observed in the North Platte River Valley. No winter roosting sites have been identified on the Forest, but suitable habitat exists, and it is possible that roosting occasionally occurs.

Raptor surveys were conducted in June and July of 1992 in the Red Hill and Pass Creek watersheds. A total of 24,000 acres was surveyed. No bald eagles or their nests were located.

Habitat:

Wintering bald eagles tend to congregate in areas of abundant prey. They use sheltered roosts during severe weather (Grubb et al. 1989). Most roost trees are large and well foliated but offer large "windows" in the canopy sufficient for take-off and landing (Grubb and Kennedy 1982).

BLACK SWIFT

Apodidae — *Cypseloides niger*

Status:

U.S. Fish & Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/SA

Management Considerations:

No known management considerations.

Distribution:

Black swifts breed locally from S.E. Alaska, parts of western Canada southward through the pacific states and Rocky Mountains to central Utah and Colorado.

Occurrence on the Medicine Bow National Forest:

The only confirmed observation in Wyoming is in a latilong including a portion of the Medicine Bow National Forest (Snowy Range). This species winters mainly in Central America.

Habitat:

Black swifts are found in areas with rocky cliffs available for nesting. Varying from ocean cliffs to mountain ledges at elevations from sea level to 11,000 feet.

Ecology:

Nests in colonies on protected cliffs, beneath water falls. Food is flying insects.

BLACK TERN

Laridae — *Chilidonias niger*

Status:

U.S. Fish & Wildlife Service:	formerly C2
U.S.. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S1B, S3N

Management Considerations:

A species of concern because of widespread declines, fragmented distribution, and dependence on limited wetland habitats (Finch 1992). Wetlands at lower elevations are important for this species.

Distribution:

Black terns are found throughout temperate North America and Eurasia.

Occurrence on the Medicine Bow National Forest:

They nest locally in Wyoming (Finch 1992). There are breeding records from the Laramie Plains east of the Medicine Bow Mountains, and there is circumstantial evidence of breeding on the west side (Oakleaf et al. 1992).

Habitat:

Black terns inhabit shallow marshes, open areas of deeper marshes, reed bordered sloughs, ponds, lakes, and swamp grasslands.

Ecology:

Black terns may be area-limited, as they were absent from Iowa marshes under 5 ha and most common in wetlands over 20 ha (Brown and Dinsmore 1986). Breeding bird surveys denote significant declines in the Rocky Mountain region of the U.S.

BOREAL OWL

Strigidae — *Aegolius funareus*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S2B, S3N

Management Considerations:

Factors that potentially affect boreal owl populations include extraction of snags during timber harvest and by firewood cutters, which results in a loss of nesting sites (also may affect woodpecker populations). Another factor is repeated entry into stands targeted for intensive timber management under shorter rotation periods, which allows fewer trees to attain the size, age, and senescence that make them suitable for excavation of nest cavities. Clearcutting naturally would have the greatest effect. Fluctuations in populations of prey species after timber harvest (or natural fires) may also have an effect. Nesting habitat can be managed through snag, old growth, woodpecker, and aspen management considerations. Strategies include maintaining specific cavity trees in managed areas (a forest plan standard and guideline), and provision of long-term availability of large, diseased trees by setting aside areas with extended rotation periods within management units (accomplished with designated old growth areas on this forest). Nest snags should be >12 inches dbh and be part of an intact forest stand. Maintaining a dispersion of small aspen stands of large diameter trees, where feasible, in proximity to old growth spruce-fir stands can provide adequate nesting habitat. Timber management that is compatible with abundant small mammal populations should be practiced in boreal owl range (Reynolds et al. 1989; Spahr et al. 1991).

Distribution:

Boreal owls are circumpolar in distribution. As the name implies, they are found in boreal, mainly coniferous, forest in both North America and Eurasia. Until the 1960's, the species was believed to be only a rare, winter migrant south of Canada. Since then, nesting populations of these owls have been found in Minnesota, Washington, and in the Rocky Mountains as far south as northern New Mexico. Throughout their range in the Rocky Mountain West, the boreal owls have mainly been found in higher-elevation conifers, primarily spruce-fir, but also in lodgepole pine and Douglas fir habitats immediately adjacent to the spruce-fir zone (Hayward et al. 1987; Ryder et al. 1987; Reynolds et al. 1989; Hayward and Verner 1994).

Occurrence on the Medicine Bow National Forest:

Garber et al. (1991) compiled a listing of 50 boreal owl observations that occurred in Wyoming from 1927-89 from records which included museum specimens, photographs, limited surveys, and incidental observations. Most observations were from Grand Teton National Park and southeastern Carbon County in the Snowy Range and Sierra Madre Range. Four nesting pairs were documented in northern Larimer County, Colorado (Ryder et al. 1987). A boreal owl was observed on Brush Creek District near the junction of the Cedar Pass Road (FDR 261) and Harden Creek Road (FDR 201) in October of 1992 (Greg Eaglin, Brush Creek District Fisheries Biologist, personal communication). This observation was in the Pass Creek watershed.

Habitat:

Boreal owls occur in subalpine forests througoout the Rocky Mountains in a variety of forest types including aspen, lodgepole pine and spruce-fir forests. Some aspects of nesting, roosting and foraging all appear associated with older forest stands (Hayward et al 1993; Hayward and Hayward 1993).Roosting and foraging habitat during winter appears less restricted than in summer. In winter they may move down in elevation and roost in protected forested areas (Hayward et al.; 1987; Spahr et al. 1991).

Ecology:

The high association with high-elevation, old growth spruce-fir forests is due to their dependence on this forest type for foraging year round. Boreal owls prey primarily on small mammals, with red-backed voles making up the highest proportion of their diet. Habitat management for long-term abundance of red-backed voles will support boreal owl populations. In the Rocky Mountains, red-backed voles occur almost exclusively in forested habitats and are far more abundant in forests with mature and old-forest characteristics (Hayward and Hayward 1995). Maintaining fungi and lichen abundance may be a critical component of maintaining important small mammal prey populations Hayward 1994; Hayward and Rosentreter 1994). Ongoing studies suggest that red-back vole populations do not decline dramatically following group selection harvest (Hayward, unpublished data). They will also take other small mammal species, birds, and some insects. Boreal owls nest in cavities excavated by larger woodpeckers and northern flickers (Spahr et al. 1991; Ryder et al. 1987). Nesting habitat structure consists of forests with a relatively high density of large trees (>12 inches DBH), open understory, and a multi-layered canopy. They avoid open areas, such as clearcuts and open meadows, except for occasional use of the edges of openings for foraging.

BURROWING OWL

Strigidae — *Athene cunicularia*

Status:

US Fish & Wildlife Service:	formerly C2
U.S. Forest Service :	sensitive
Wyoming Natural Diversity Database:	G4/S3B, SZN

Management Considerations:

Burrowing owls are associated with prairie dog colonies.

Occurrence on the Medicine Bow National Forest:

They are believed present on all mountain areas of the Medicine Bow National Forest, but specific population data is lacking.

Habitat:

Open grasslands at lower elevations.

Ecology:

A neotropical migratory bird species which winters in central America.

COLUMBIAN SHARP-TAILED GROUSE

Phasianidae — *Tympanuchus phasianellus columbianus*

Status:

US Fish & Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S1

Management Considerations:

The Wyoming Natural Heritage Program lists this species as critically imperiled in Wyoming. Reasons for this status are that it is scarce, reproductively isolated, and exposed to herbicidal rangeland treatment and agricultural practices.

Distribution:

The Columbian sharp-tailed grouse historically occurred in western North American from British Columbia southward to California and Colorado. It has been reduced to remnant populations throughout its former range due to unregulated hunting, agriculture, energy development, and habitat fragmentation (several citations in Finch 1992).

Occurrence on the Medicine Bow National Forest:

Occurrence on the Medicine Bow National Forest:

Known only from south central Wyoming in the western and southern Sierra Madre Range foothills adjacent to the Washakie Basin of southwest Carbon County. Leks are known from the Hayden Ranger District.

Habitat:

Mountain shrub habitats dominated by Gambel oak, serviceberry, big sagebrush, and mountain snowberry. In south central Wyoming, a population was studied in mixed shrub rangeland, rich in forbs and grasses. Brood habitat was characterized by a higher frequency occurrence of snowberry. In fall, use ridges and knolls of mountain shrub habitats and also riparian areas during winter (Oedekoven 1985). Another Wyoming study found that Columbian sharp-tailed grouse and sage grouse both occured in shrub-steppe communities dominated by sagebrush and other shrubs such as rabbitbrush, bitterbrush, and chokecherry but uses the mountain shrub and sagebrush-snowberry habitat more (Klott and Lindzey 1990). Elevation 6,500 - 8,200 ft.

In Wyoming, breeding records are from the western and southcentral parts of the state. Remnant populations in southcentral Wyoming breed in mountain shrub communities in the Baggs-Savery area and lower elevations on the west slope of the Sierra Madre Range. Brood habitat in Wyoming shrublands is characterized by greater forb and grass cover and higher frequency of snowberry than adjacent habitats (Oedekoven 1985 cited in Finch 1992).

Ecology:

Like other grouse, males compete for females by displaying in leks. Leks are areas of low vegetation with good visibility. Males defend a territory within the lek and compete with other males for females.

COMMON LOON

Gaviidae *Gava immer*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S2B, S4N

Management Considerations:

There are no known management considerations.

Distribution:

The common loon breeds in Alaska, Canada, northern United States, Greenland, and Iceland (Finch 1992). In Wyoming, loons are known to

nest in the western part of the state, however, there are no nesting records from Carbon County (Oakleaf et al. 1992).

Occurrence on the Medicine Bow National Forest:

There are a number of lakes that provide potential loon breeding habitat on Brush Creek District, however most are at higher elevations in the eastern and northeastern parts of the District. The only lake of significant size is Moerke Lake in the eastern part of Pass Creek watershed. The lake is ten acres in size, at an elevation of 8,880 feet, and has a maximum depth estimated at three feet. There are no spawning areas, as there are no inlets or outlets. Winterkill problems would occur frequently. The lake is essentially a bog with extremely dense aquatic vegetation. The lake is considered unsuitable for fish (Snigg 1989). For these reasons, it is extremely unlikely that loons would breed on this lake.

Habitat:

Loons breed on large (greater than nine acres), clear lakes at elevations from 5-9,000 feet, and are primarily fish-eaters. Lakes need to be ice-free for a minimum of four months with at least partially forested shorelines. Loons need lakes large enough to provide adequate runways for flight, deep enough to sustain fish populations, and clear enough for them to see their prey (Spahr et al. 1991).

FERRUGINOUS HAWK

Accipitridae *Buteo regalis*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S4B, SZN

Management Considerations:

There are no known management considerations.

Distribution:

This is a neotropical migratory bird that breeds from southern Canada to the central plains and winters in Mexico and the southwestern United States.

Occurrence on the Medicine Bow National Forest:

Ferruginous hawks appear to be incidental on the Medicine Bow National Forest. The Wyoming Game and Fish Wildlife Observation System database lists only two ferruginous hawk observations (not nests) in the Bitter Creek area in the Red Hill watershed. Both observations were in the

fall of 1973. No ferruginous hawks were observed in the project area watersheds during raptor surveys conducted in 1992.

Habitat:

Ferruginous hawks prefer relatively unbroken terrain of the semiarid western plains and arid intermountain regions. This would include areas primarily east and west of the Snowy Range, however, they also may hunt in openings at higher elevations on NFS lands. They nest in trees and bushes, and on ledges, large rocks, riverbanks, and hillsides (Reynolds 1989). This hawk depends on native grasslands where nest sites are scarce, and as a consequence, individuals often reuse nest sites (Finch 1992). The species has been known to breed throughout Wyoming (Oakleaf et al. 1992), but no nest sites are known to occur on the Forest.

FLAMMULATED OWL

Strigidae — *Otus flammeolus*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S3?B, SZN

Management Considerations:

Ponderosa pine forest, of limited occurence in the Sierra Madre and Medicine Bow Mountains, has probably decreased in abundance this century due to early harvests and fire suppresssion. More habitat is available in the Laramie and Sherman Mountains. Open understories are desireable.

Distribution:

This owl inhabits montane forests of western North America. In the Rocky Mountains, this owl is typically found in the dry pine belt, foraging primarily in late successional stands of ponderosa pine that are pure or mixed with oak, pinyon pine, true fir, Douglas fir, or aspen (Reynolds and Linkhart 1987; Reynolds et al. 1989).

Flammulated owl nests have been reported in all western states except Wyoming and Nevada (Reynolds et al., 1989; Oakleaf et al. 1992). Known breeding range includes National Forests in northcentral Colorado. In Wyoming, they have been observed locally (not breeding) in the central and northwest parts of the state.

Occurrence on the Medicine Bow National Forest:

Status of flammulated owls is not known. They would be expected in the Laramie Mountains.

Habitat:

Flammulated owls nest in natural cavities or in cavities excavated by both small and large woodpeckers. Trees, both live and dead, used for nesting are ponderosa pine, quaking aspen, and Douglas fir. The affinity of flammulated owls for old ponderosa pine forests stems from the abundance of nest cavities, the structure of the trees and stands, and the arthropods found in these forests.

Ecology:

They are almost exclusively insectivorous, preying on small to medium sized moths, beetles, caterpillars, and crickets. Flammulated owls are nocturnal foragers and hunt by gleaning among tree branches, hawking or capturing of flying insects, and pouncing on ground prey from a perch (Spahr et al. 1991). There are more moth species, many of which are active on cold nights in spring and early summer, associated with ponderosa pine and Douglas fir than with other western conifers. The specific hawking and gleaning tactics used during foraging, most of which occur within tree crowns and occasionally in the space between trees, requires the maneuvering room provided by the open crowns and park-like spacing of trees in these old growth stands (Reynolds et al. 1989).

FOX SPARROW

Emberiziadae *Pasarella iliaeca*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S5B, S5N

Management Considerations:

There are no known management considerations.

Distribution:

The fox sparrow is a common resident that breeds from Alaska and the Yukon eastward to Quebec and northern Labrador, and south in western mountains to southern California and central Colorado. Wintering birds are found through the Pacific states to Alaska, the gulf states, and at the eastern base of the Rocky Mountains.

Occurrence on the Medicine Bow National Forest:

There is no information on populations of fox sparrows on the Medicine Bow National Forest.

Habitat:

This species is fairly nonspecific in its requirements, needing only dense, shrubby undergrowth. They inhabit a wide variety of habitats throughout their range including the undergrowth of deciduous or coniferous forests, brushy woodland edges, woodland thickets, burned coniferous and

logged/thinned forests, riparian woodlands, willow thickets (especially with adjacent coniferous forest), and montane coniferous scrub. Nests are usually on the ground, occasionally in a shrub, and are well-concealed by surrounding tangles of vegetation.

Ecology:

Feeds primarily on insects in summer and on seeds of weeds and some grasses in winter (DeGraaf et al. 1991; USDA Forest Service 1981). Breeding records in Wyoming occur along the Montana border, throughout the western part of the state, and along the Colorado border. There are no breeding records from the eastern plains areas (Oakleaf et al. 1992).

GOLDEN-CROWNED KINGLET

Muscicapidae *Regalus statrapa*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S4B, S5N

Management Considerations:

The habitat is old growth forests. They are senstiive to disturbance on breeding grounds.

Distribution:

This uncommon, yearlong resident ranges widely from southern Alaska south throughout Canada, to southern California in both the coastal and interior ranges, through the Rocky Mountain states to Mexico, and in much of the eastern United States.

Occurrence on the Medicine Bow National Forest:

There have been no population surveys for this species.

Habitat:

Breeds primarily in dense coniferous forests, especially where spruce is present, but may also be found in old lodgepole pine, Douglas-fir, and mixed aspen-conifer stands. Winters in coniferous forests and occasionally in deciduous woodland scrub and brush. Kinglets build a globular nest that is woven into the twigs of a horizontal limb near the trunk of a conifer.

Ecology:

Foods include insects, tree sap, fruits, and some seeds (DeGraaf et al. 1991; USDA Forest Service, 1981). The golden-crowned kinglet breeds through most of western Wyoming and in the southcentral part of the state, including the latilong in which the project area occurs (Oakleaf et al. 1992). Kinglets are more tolerant of ecological change in winter and during migration, but exhibit little tolerance to changes on nesting grounds.

during migration, but exhibit little tolerance to changes on nesting grounds.

LEWIS' WOODPECKER

Picidae *Melanerpes lewis*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S38, SZN

Management Considerations:

There are no special management considerations known.

Distribution:

Lewis' woodpeckers breed from southern British Columbia south through most of the western states, and east to southwestern South Dakota and northwestern Nebraska. In Wyoming, Lewis' woodpecker breeds in all areas of the state with low mountain ranges, or foothill areas of larger mountain ranges.

Occurrence on the Medicine Bow National Forest:

No surveys for Lewis' woodpeckers have been done. A recent Master's thesis examined populations at the southern end of the Laramie Mountains which included some NFS land area (Linder 1994)

Habitat:

This species inhabits open country with scattered trees rather than dense forests. Open or parklike ponderosa pine forests are probably the major breeding habitat. Lewis's woodpeckers are also attracted to burned-over stands of Douglas-fir, mixed conifer, pinyon-juniper, riparian, and oak woodlands, and may also be found in fringes of pine and juniper tree stands and in deciduous forests, especially riparian cottonwoods (DeGraaf et al. 1991; Oakleaf et al. 1992).

Ecology:

The areas without breeding records coincide for the most part with the Powder River Basin, the Great Divide Basin, and the Bighorn Basin.

LOGGERHEAD SHRIKE

Laniida — *Lanius ludovicianus*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4G5/S4B, SZN

Management Considerations:

There are no known management considerations.

Distribution:

The loggerhead shrike is a common to uncommon summer resident of the western, central, and southeastern United States, observed primarily in open habitats with scattered perching sites.

Occurrence on the Medicine Bow National Forest:

No surveys have been done, but the species is known to occur in the Laramie Mountains and Sherman Mountains.

Habitat:

In the Rocky Mountains, it ranges altitudinally from agricultural lands on the prairies to montane meadows, nesting in sagebrush areas, desert scrub, pinyon-juniper woodlands, and woodland edges (Johnsgard 1986). Breeding bird surveys from 1966 to 1987 indicate sharp population declines in loggerhead shrikes throughout the western, central, and eastern United States (Robbins et al. 1986 in Finch 1992).

Ecology:

It is most likely to be found at lower elevations on NFS lands in Wyoming. Nests are usually hidden below the crown in the crotch or low branch of a deciduous tree or shrub. Shrikes feed on insects, small vertebrates, and carrion. Breeding records in Wyoming are from every part of the state except the extreme northwestern corner (Oakleaf et al. 1992).

LONG-BILLED CURLEW

Scolopacidae — *Numenius americanus*

Status:

U.S. Fish and Wildlife Service:	formerly C3
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S2B, S3N

Management Considerations:

Early season grazing may affect long-billed curlew breeding.

Distribution:

This is a neotropical migratory bird which breeds from southern Canada to the Great Plains and winters in Central America.

Occurrence on the MBNF:

Potential occurrence on the Medicine Bow National Forest would be in open areas near the Forest boundary.

Habitat:

The long-billed curlew inhabits grasslands, moist meadowland, sagebrush grasslands, and mountain foothills. There are breeding records throughout Wyoming including this area (Oakleaf et al. 1992; DeGraaf et al. 1991).

MERLIN

Falconidae *Falco columbarius*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G3/S2B, S2N

Management Considerations:

There are no known management considerations.

Distribution:

Holarctic distribution.

Occurrence on the Medicine Bow National Forest:

No merlins were observed during raptor surveys conducted in 1992 in the Sierra Madre Mountains. They use most habitats below 8,500 feet, and could potentially occur along the forest edge at low elevations. Habitat on the MBNF is limited.

Habitat:

Merlins inhabit open areas such as forest edges, bogs, and lakes in boreal and moist Pacific Coastal forests, and prairie-parkland of the northern Great Plains (DeGraaf et al. 1991). Nests often are in an old nest of other species, usually magpie, in coniferous or deciduous trees. Merlins have been observed breeding in most parts of Wyoming, but there are no records from this part of Wyoming (Oakleaf et al. 1992).

MOUNTAIN PLOVER

Charadriidae — *Charadrius montanus*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G3/S2B, S2N

Management Considerations:

No known specific considerations at this time, but the species is under study.

Distribution:

This species breeds from southern Canada to Texas and Oklahoma and winters in southern California and Mexico.

Occurrence on the Medicine Bow National Forest:

Occurrence on the Medicine Bow National Forest is not confirmed.

Habitat:

The mountain plover is a species of the high plains and arid regions of western valleys and hills, usually found far from water. Mountain plovers generally avoid mountainous areas and prefer short-grass prairie, often in association with prairie dogs (DeGraaf et al. 1991; Finch 1992). There are breeding records for this species throughout most of Wyoming, including Carbon County (Oakleaf et al. 1992).

NORTHERN GOSHAWK

Accipitridae — *Accipiter gentilis*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G4/S2B, SZN

Management Considerations:

Management recommendations for goshawks have been developed for the Southwest Region (R3) of the Forest Service (Reynolds 1983, 1991; Reynolds et al. 1992). Removal of mature and older forest age groups reduces availability of preferred nesting and foraging habitat. Clearcuts, seed tree or shelterwood harvests that result in thick regeneration reduce the availablity of foraging habitat. Created openings may benefit other, more competitive forest raptors such as long-eared owls, red-tailed hawks

and great-horned owls, which may prey on goshawks. Goshawks may abandon nests if disturbed during the breeding season.

The status of goshawk population in terms of population viablity is unknown, especially given poor reproductive success during the past two years (Squires 1995). Recent Forest Service Research studies (Squires and Ruggiero 1996) on goshawk habitat on the Medicine Bow National Forest indicate that preferred goshwak nest stands were in single-storied mature forest stands with high canopy closure and clear forest floors. Management recommendations will be submitted.

Distribution:

Goshawks breed from western and central Alaska to the Rocky Mountains and east to the Applachian mountians. They winter throughout the breeding range and south of it.

Occurrence on the Medicine Bow National Forest:

There are about 50 known nesting territories on the MBNF (Squires 1995). A search of Brush Creek District records revealed four known goshawk nest locations in the Red Hill area (Squires 1995). With the upgrading of the northern goshawk to Category 2 status by the U.S. Fish and Wildlife Service in November of 1991, additional funding became available for monitoring threatened, endangered, candidate, and sensitive species on the Medicine Bow National Forest (MBNF). In a cooperative effort between researchers from the Rocky Mountain Station in Laramie and MBNF biologists, a goshawk/raptor sampling protocol was developed for use on District raptor surveys. A line-transect sampling unit protocol was developed as a modification of a sampling method developed by Dr. Patricia Kennedy and others in the southwestern United States. A description of methods is on file in the Brush Creek District Office in Saratoga, WY.

Goshawk/raptor surveys were conducted in Brush Creek timber sale watersheds in 1992. A total of 24,000 acres was surveyed, which represents most of the potential goshawk habitat in the two watersheds. Ten active goshawk nests and two alternate nests were found during the period of June-August, 1992 in the two project area watersheds. Six were discovered while conducting surveys along transects. Two more were located by field personnel during follow-up searches in areas where the District wildlife crew observed goshawks but was unable to locate the nest. Two additional active nests were discovered by other field personnel working within these watersheds. Of the ten nesting territories discovered in 1992, two appear to coincide with the active nests recorded in older District records. The other eight represent newly discovered breeding territories. Only a small portion of the total area surveyed occurred in high elevation spruce-fir old growth forest. No active nests were found in

this vegetation zone, although goshawks have been observed. It is possible these observed birds represent an additional breeding territory, however, the area is within the foraging range of several breeding territories at lower elevations. All of the active nests were found between 8,000 and 8,850 feet in elevation in mostly lodgepole/aspen forest. One nest was in a subalpine fir, the rest were in lodgepole pine and aspen trees. All but one of the active nests were in areas with no timber harvest (the former Pennock Mountain RARE II area) or areas with limited timber harvest. One nest was located in the harvested eastern part of the Pass Creek watershed. In forests fragmented by timber sales in the Sierra Madre, many active goshawk nests were found. Consistency of occupancy may be affected by patch size, but viability of goshawk nests in fragmented areas is unknown (Squires 1995).

In addition to the goshawk nests mentioned above, one red-tailed hawk nest and one sharp-shinned hawk nest were discovered in the two project area watersheds during the surveys. Also, a timber crew marking cutting units for the Harden-Mullison timber sale in an adjacent watershed (Mullison Park watershed) located three additional active goshawk nests in that watershed.

A field crew from the Rocky Mountain Station in Laramie monitored the 1992 active goshawk nests during the 1993 and 1994 field seasons. Six active nests were found in 1993; 16 in 1994 and four (one failed) in 1995 (Squires 1995). One new active goshawk nest was also discovered in 1993. It is not known if this breeding pair is a pair that had an active nest in 1992 and moved to an alternate nest in 1993. There were several other active territories in the vicinity of this nest in 1992.

No new active territories were discovered by the District wildlife technician during goshawk inventories conducted in other watersheds (Sawmill Park, Jim Draw, and Middle French) in 1993. Low breeding activity in 1993 was also observed on other MBNF Districts. Consensus attributes this to the very wet and cold spring and early summer experienced in this area in 1993. It is believed that it was simply a very poor reproductive year for goshawks (Squires 1995).

On the Laramie District, goshawk/raptor surveys were conducted in June/July 1993 for the White Swan Holmes timber sale area. No goshawks or nests were found in 1993, but three active nests were found in 1994 (Squires 1995). As of 1993, about 30,000 acres had been surveyed in the Sierra Madre Mountains. Since 1984, 47 active nests have been located. One nest was found in the Sherman Mountains in 1994 and

two more in the Fall Creek Timber Sale area in 1995 (Squires 1995). See Haas (1993) for a full discussion.

Habitat:

The northern goshawk is the largest of the North American accipiters. Goshawks breed in coniferous, deciduous, and mixed forests throughout much of North America (Sisson and Nolde 1978; Reynolds et al. 1992). The goshawk occurs in all major forest types, but the preferred habitat for the MBNF population appears to be lower elevation, mature open lodgepole pine stands with some aspen for nesting (Squires 1995). Preferred habitat during the breeding season is older, tall forests where goshawks can maneuver in and below the canopy while foraging and where they can find large trees in which to nest (Reynolds 1989). In the Rocky Mountains, goshawks frequently nest in dense stands of mature lodgepole pine or quaking aspen stands (Jones 1979). Because of its relatively large body size and wing span, the goshawk does not often use dense, young forest stands.

Ecology:

A goshawk's nesting home range may be up to 6,000 acres. Reynolds et al. (1992) identified three main components needed within this home range for southwestern forests. The nest area is 30 acres or more and may include more than one nest. Nest areas contain one or more stands of large, old trees with a dense canopy cover. Most goshawks have alternate nest areas within their home range that may be used in different years. The post fledging-family area (PFA) is approximately 420 acres and surrounds the nest area. Because of its size, the PFA typically includes a variety of forest types and conditions. It represents an area of concentrated use by the family from the time the young leave the nest until they are no longer dependent on the adults for food (up to two months). These areas are important for fledglings since they provide hiding cover and prey on which to develop hunting skills. PFA's have patches of dense trees, developed herbaceous and/or shrubby understories, and habitat attributes such as snags, downed logs, and small openings that provide necessary habitat for many goshawk prey species. The foraging area is approximately 5,400 acres in size, and surrounds the PFA. Hunting goshawks use available habitats opportunistically.

This suggests that the choice of foraging habitat may be as closely tied to prey availability as to habitat structure and composition. Goshawks hunt from tree perches by scanning lower portions of the forest for prey (on the ground and in the lower canopy). Because of visual limitations in dense forest environments, an open understory enhances detection and capture of prey. Also, because of their size, goshawks prey on the larger forest birds such as woodpeckers, jays, and grouse, as well as red squirrels and

chipmunks. The majority of these prey species reside mainly on the ground and in lower portions of the tree canopy.

In high elevations and montane areas, some goshawks descend to lower elevation into woodlands, riparian areas, and scrublands during winter. Recent radio telementry studies by researchers at the Rocky Mountain Station in Laramie also indicate that goshawks on the Medicine Bow National Forest (MBNF) also migrate off National Forest summer breeding areas southward into Colorado and westward to lower elevation non-forested areas (Squires and Ruggiero 1995).

NORTHERN THREE-TOED WOODPECKER

Picidae — *Picoides tridactylus*

Status:

U.S. Fish and Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S3B, S5N

Management Considerations:

Because woodpeckers require snags for feeding, perching, nesting, and roosting, habitat can be removed by clearing of forests without snag retention. Fire suppression that eliminates fire-killed trees is also a threat. They need snags that are at least 12-16 inches in dbh, and because they forage by scaling (they peel the bark off snags to expose their prey), snags with the majority of their bark should be present (Spahr et al. 1991).

Distribution:

They are found from Alaska, across Canada, and in the Rocky Mountains south to Arizona and New Mexico.

Occurrence on the Medicine Bow National Forest:

Three-toed woodpeckers have recently been observed breeding in the Snowy Range (Loose, 1993). In Wyoming forests fragmented by clearcuts, this woodpecker was found only in large, unbroken stands of mature spruce-fir and lodgepole pine (Keller 1987).

Habitat:

Northern three-toed woodpeckers are found in western coniferous forests. This uncommon, inconspicuous woodpecker can be found in open or dense stands of pine, spruce, and fir, especially where fires have left large stands of dead trees (DeGraaf et al. 1991).

Ecology:

After a forest fire, woodpecker numbers may swell for 3-5 years in or near burned stands, then decline to pre-fire population levels (Taylor and Barmore 1980). The three-toed woodpecker scales bark off fire-killed trees to expose it's most commom prey, bark-boring beetles. Nest holes excavated by this species are used by a wide variety of secondary cavity-nesting birds long after the woodpecker has left the area (Finch 1992). Breeding records for Wyoming occur in most mountainous areas in the state except for the Black Hills (Oakleaf et al. 1992).

OLIVE-SIDED FLYCATCHER

Tyrannidae — *Cantopus borealis*

Status:

U.S. Fish & Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S5B, SZN

Management Considerations:

This species is associated with, and appears to be dependent on old growth forest and associated wetlands which serve as breeding areas for insects. This species is also associated with burned over areas with tall standing dead trees. Loss of tall perch snags due to clearcutting, firewood cutting, and stand conversion to younger seral stages (shorter rotation age) may negatively affect flycatcher populations (DeGraaf et al. 1991; Finch 1992; USDA Forest Service 1981).

Distribution:

This long-distance migrant breeds in Alaska, across Canada, and in the western and northeastern United States (Udvardy 1977), and winters in northern South America. In Region 2 it is a fairly common summer resident in the high mountains of Colorado and Wyoming. Breeding has been recorded for most of Wyoming with the exception of the eastern plains and Powder River Basin areas (Oakleaf et al. 1992).

Occurrence on the Medicine Bow National Forest:

It is a fairly common summer resident in all four mountain areas of the Medicine Bow National Forest, but specific population data is lacking.

Habitat:

Preferred habitat is older aged coniferous forests with adequate snags or dead topped trees which provide tall exposed perches, especially those bordering mountain grasslands, bogs, and meadows. Normally found from 8000 ft. to timberline.

Ecology:

Most often observed perching, singing, or catching insects at or near the tops of tall trees and snags. Its affinity for unusually large trees may be a factor limiting its abundance and distribution. Nests are usually 5 to 15 meters in height, well hidden in conifer branches (Johnsgard 1986). Olive-sided flycatcher populations have precipitously declined in the west over the last 30 years.

OSPREY

Pandionidae — *Pandion haliaetus*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S3B, S5N

Management Considerations:

There are no known management considerations other than snag retention.

Distribution:

Widely distributed in in North America.

Habitat:

The osprey is a cosmopolitan species, historically breeding along seacoasts, lakes, and streams throughout woodlands and forests of North America. They occupy a wide range of habitats in association with waters containing adequate supplies of fish, their primary food.

Occurrence on the Medicine Bow National Forest:

The Wyoming Game and Fish Wildlife Observation System database contains 28 osprey sightings (not nesting records) on Brush Creek District since 1982. Most of the observations are in an area between Turpin Reservoir, Long Lake, and the East Fork of the Medicine Bow River. According to District records, a pair of osprey maintained a nest in a snag at Stillwater Park for several years, however, it was blown down in a storm circa 1990. According to District personnel, another raptor nest has been constructed in Stillwater Park, and it is believed osprey have re-nested. Stillwater Park is about three miles east of Pass Creek watershed.

Ecology:

Ospreys construct large, bulky nests in broken-topped trees and snags, and on artificial platforms. Snags or dead-top trees near water are preferred perching, hunting, and resting sites (DeGraaf et al. 1991; Finch 1992).

PEREGRINE FALCON

Falconidae *Falco peregrinus*

Status:

U.S. Fish and Wildlife Service:	Endangered
U.S. Forest Service:	none
Wyoming Natural Diversity Database:	G4/S1B, S3N

Management Considerations:

No special management considerations known.

Distribution:

This species breeds in the northern U.S. and Canada and winters from the southern U.S. to South America.

Habitat:

Rocky cliffs, preferably near wetlands.

Occurrence on the Medicine Bow National Forest:

There are no nesting records for the peregrine falcon on Brush Creek District (Oakleaf et al. 1992). Escarpments along the North Platte River in the Platte River Wilderness area on Hayden District are considered marginal habitat. The Wyoming Game and Fish Wildlife Observation System database only has one recorded observation (not nesting) for peregrine falcons on Brush Creek District, and this was in the vicinity of Libby Flats in 1978. No peregrine falcons or nests were observed during raptor surveys conducted in the two watersheds in 1992. Duffy (1976) surveyed potential habitat on the Laramie Ranger District.

Ecology:

Peregrine falcons are typically found in open country near rivers, marshes, and coasts. The peregrine's diet consists primarily of a wide variety of birds including pigeons, shore birds, waterfowl, and grouse (Spahr et al. 1991). Open areas, especially along rivers and flood plains afford the best foraging habitat. Cliffs are preferred nesting sites; however, peregrines are also known to occasionally nest on slopes and river cutbanks, mounds, an occasional sand dune, and flat bogs and plains (Snow 1972).

PURPLE MARTIN

Hirundinidae *Progne subis*

Status:

U.S. Fish & Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S4B, S4N

Management Considerations:

Depends on woodpecker cavities or natural tree hollows in forested environments. Old aspen stands and aspen forests are important habitat. Though common in the East, it is scarce and evidently declining in the West, possibly because of nest-site competition with starlings (Udvardy 1977). Western martins inhabit deciduous riparian woodlands, aspen stands, open coniferous forests, burns with snags, woodland edges, and urban areas.

Distribution:

The purple martin breeds from southern Canada to northern Mexico, but populations are small and scattered in the Great Basin and Rocky Mountain states. It winters in South America. There are recent observations (not breeding) of martins in Wyoming (Oakleaf et al. 1992). In Wyoming this species is expected to be found below 7,000 feet elevation.

Occurrence on the Medicine Bow National Forest:

Its status is unknown on the Medicine Bow National Forest, and specific population data is lacking. A purple martin has been observed in an aspen cavity at lower elevations on the Routt National Forest by other biologists, however, the martins were displaced by house wrens (Deborah Finch, Research Wildlife Biologist, Rocky Mountain Forest and Range Experiment Station, Flagstaff, AZ, personal communication).

Habitat:

Western purple martin inhabit deciduous riparian woodlands, aspen stands, open coniferous forests, burns with snags, woodland edges and urban areas.

Ecology:

Unlike eastern martins that nest communally in multiple-compartment houses, western populations typically nest in tree holes excavated by woodpeckers, eaves of buildings, or natural tree hollows. In southwestern and west-central Colorado, purple martins reside locally in pure stands of mature aspen, nesting alone or in loose colonies in woodpecker cavities (Finch 1992). Ranging from 4 to 13 cm. in height, nest holes are selected in large aspens typically adjacent to forest openings or parklands (Finch 1992).

PYGMY NUTHATCH

Sittidae *Sitta pygmaea*

Status:

U.S. Fish & Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/ S4B, S5N

Management Considerations:

Cavity-nesting birds of ponderosa pine forests. May use aspen trees also.

Distribution:

Local resident of pine forest types throughout the western United States. Pgymy nuthatches have been observed in many parts of Wyoming with breeding records from the Black Hills, Bighorn Mountains, Laramie Mountains and Sherman Mountains.

Occurrence on the Medicine Bow National Forest:

Specific population data is lacking.

Habitat:

Pygmy nuthatches are generally associated with ponderosa pine forests. They prefer open, parklike habitat, especially among ponderosa pines in the lower coniferous forest zone.

Ecology:

These small nuthatches usually excavate nest cavities near the top of a dead pine where the wood is well rotted, or the underside of a dead branch about 5-60 feet above the ground. They may occasionally nest in aspen snags or abandoned woodpecker holes. Foods are primarily insects and conifer seeds. Winter flocks often roam with chickadees and crossbills.

SANDHILL CRANE

Gruidae *Grus canadensis*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S4B, S4N

Management Considerations:

There are no known management considerations

Distribution:

In the West, the greater sandhill crane breeds from the Arctic coast south to northeast California and northern Colorado (Finch 1992). In Colorado

an isolated population breeds in willow riparian areas in California Park on the Routt National Forest. This crane nests locally in marshes, mountain meadows, and riparian habitats in western Wyoming. Oakleaf et al. (1992) indicate breeding records in this part of Wyoming.

Occurrence on the Medicine Bow National Forest:

A breeding pair was observed just off NFS lands north of Bow River Work Center in 1991 (Dave McKee, District Archeologist, personal communication). Sandhill cranes were observed in riparian areas along Lee and Rankin Creeks near the Forest boundary in 1992 by Jerry Mastel (Brush Creek District biologist). No nests were discovered.

UPLAND SANDPIPER

Scolopacidae — *Bartramia longicauda*

Status:

U.S. Fish and Wildlife Service:	none
U.S. Forest Service:	sensitive
Wyoming Natural Diversity Database:	G5/S2B, S3N

Management Considerations:

There are no known management considerations.

Distribution:

The upland sandpiper breeds from Alaska through the Canadian prairie and the northern United States south to Colorado and Texas.

Occurrence on the Medicine Bow National Forest:

Occurrence is likely incidental.

Habitat:

It inhabits native prairies, open grasslands, upland clearings, hayfields, and wet meadows. It generally avoids tall grass and shrub-steppe grasslands (Finch 1992). There are breeding records from eastern and central Wyoming (Oakleaf et al. 1992). The species has been observed in this part of Wyoming, but there are no breeding records.

WHITE-FACED IBIS

Threskiornithidae — *Plegadis falcinellus*

Status:

U.S. Fish & Wildlife Service:	formerly C2
U.S. Forest Service:	sensitive
Wyoming Natural Heritage Database:	G5/S1B, S2N

Management Considerations:

Populations of white-faced ibis may be affected by trophic concentrations of pesticide residues (Capen 1977). Beaver ponds and kettleholes are habitat.

Distribution:

Local and intermittent throughout much of the west central U.S. in the summer and a casual vagrant as far north as southern Alberta.

Occurrence on the Medicine Bow National Forest:

Ibises have been observed in this part of Wyoming and on the east side of the Medicine Bow Mountains. There are no documented nesting records (Oakleaf et al. 1992). Riparian areas at lower elevations near the forest boundary provide potential habitat.

Habitat:

White-faced ibis inhabit wetland habitats, preferably marshes and sloughs or ponds surrounded by low bushes or willows, and emergent vegetation, such as bullrushes. Recently irrigated pasture land is a preferred foraging habitat.

Ecology:

Nesting colonies are located in shrubs and low trees or in dense standing reeds and tules near or in marshes (Finch 1992). Ibises feed on crayfish, frogs, grasshoppers, and other invertebrates in shallow ponds, marshes, irrigated lands, and wet meadows.

NEOTROPICAL MIGRATORY BIRDS

Declines in populations of Neotropical migratory birds (NTMB) over the past several decades have been documented by avian surveys. While the exact rates and extent of declines have yet to be determined, the need for conservative action remains apparent. A concerted effort with Latin and South American countries to continue and increase neotropical migrant monitoring throughout the entire year, and to retain suitable habitats for migrants in North America as well as in Central and South America, is needed. In addition, there exists a need for conservation education in Central and South American deforesting nations, as the ability to achieve sustainable human development at southern latitudes is critical for the continuance of sustainable avian populations (Finch 1991a).

Presence of neotropical migrants enhances species richness, while the decline or loss of migrant species may indicate decreases in overall ecological integrity of ecosystems. Management of neotropical migrants raises the question of quantity verses quality. It would seem not enough to manage only for maximum avian

density; management direction must also keep in mind the need for ecological integrity, ensuring that all native species are represented at viable levels.

Every year approximately 250 species of birds breed in North America during the spring and summer seasons, then migrate south to winter in the regions between the Tropic of Cancer and the Tropic of Capricorn (Finch and Stangel 1992); Robertson 1991). One hundred twenty one species are known from the Medicine Bow National Forest (Table 8.11). National Breeding Bird Surveys have revealed that since the 1940s many forest-dwelling birds, including a number of migrating neotropical species, have experienced widespread population declines (Finch, 1991a).

Current declines in neotropical migrants may be attributed in part to both fragmentation of North American breeding habitats and to loss of Southern habitats resulting from the deforestation of avian wintering grounds (Finch 1991b, Robertson 1991, Mauer 1992, Manley et al. 1993).

Research indicates that some neotropical migrants may possibly maintain lower populations and thus may be more sensitive to human induced habitat change; therefore some neotropical migrants may at times experience greater rates of decline and extinction than some resident species (Mauer, et al. 1992). As evidence of declines in avian population accumulates, and adverse effects of habitat changes on species survival potentials becomes more clear, many individuals and organizations are recognizing the need for habitat conservation.

The Forest Service is establishing habitat conservation and avian monitoring objectives, outlining the steps necessary to achieve the desired goals. A detailed discussion of Neotropical Migratory Birds is in Appendix 10.

INTEGRATION OF NTMB INTO FOREST SERVICE POLICY

The need to establish the conservation of individual threatened or endangered species and their critical habitats as a national priority was recognized in the Endangered Species Act of 1973. The National Forest Management Act of 1976 and related mandates support the need for both floral and faunal diversity, emphasizing the importance of maintaining viable populations of native and migrating species on all Forest Service lands.

Conservation of neotropical migratory birds fits well into the Forest Service policy of Ecosystem Management, which emphasizes the need for ecological-based management of natural resources and stresses collaborative efforts by all those both affected by and affecting natural resources. The need for continued and increased monitoring operations in order to detect trends in populations and ecosystems, the need for sound management decisions based on reliable research,

and the need to establish adaptive rather than reactive management policies are characteristics of both Ecosystem Management and NTMB conservation goals (Finch et al. 1993; USDA 1994).

FOREST SERVICE ROLES AND RESPONSIBILITIES

The Deputy Chief outlined the roles and responsibilities at each Forest Service level in a 1993 NTMB monitoring report (Manley et al. 1993):

National Level

At the National level the Chief provides direction on national priorities and standards, as well as conducting nation-wide analyses and national and regional program reviews (Manley, et al. 1993). The Chief communicates with other national agencies in a cooperative framework, and facilitates the distribution of data and analysis results throughout the agency and other cooperating agencies (Manley et al. 1993).

Regional Level

The Region provides direction, provides services for Forests, and ensures that quality work is performed throughout the Region (Manley, et al. 1993). Each Region should develop a monitoring plan which includes the monitoring of neotropical species on each Forest, ensuring that the minimum Level 1 monotoring objectives are met. The Region 2 monitoring plan is not complete as of 1995.

Forest Level

While the responsibilities of Forest Supervisors vary from Region to Region and from Forest to Forest, in most instances the Supervisor is responsible for development of proposals for Level 2 and Level 3 monitoring and provides Forest-wide data collection, entry, proofing, analysis, and storage. The Supervisor also has the responsibility of incorporating monitoring results into the Forest direction and responding appropriately to trigger point cues and monitoring results (Manley, et al. 1993). There are no Level 2 or Level 3 monitoring plans for the MBNF as of 1995.

Research Stations

Research station directors conduct studies investigating the causes of population trends and design and test protocol for data collection, storage, and analysis. Station personnel also provide input in Regional Steering Committees and assist the Region in analysis and interpretation of data (Manley, et al. 1993). A bibliography of publications by Forest Service Research on NTMB is in Finch (1991a).

REGIONAL MONITORING AND CONSERVATION GOALS

In 1994, Dick Roth, neotropical migrants specialist in Region 2, outlined Regional NTMB monitoring goals. These are: 1) cooperation with the Partners in Flight (*Aves de las Americas*), and other state and federal agencies, to extend Breeding Bird Survey (BBS) routes in each state, 2) assist in completing Breeding Bird Atlas projects in order to provide information on statewide distribution and breeding status of neotropical migrants, 3) establish point count projects to conduct both forest plan level monitoring and project specific monitoring, 4) cooperate with appropriate agencies and organizations to establish four additional avian productivity sites in the Region, 5) attempt to create a regional data

repository, and 6) continue to increase and improve neotropical migrant monitoring techniques and study designs (Roth 1994).

Eight specific Regional monitoring goals were identified: 1) for 1994-1996 the Region aims to establish and run 18 new Breeding Bird Survey Routes, six in 1994 and 12 in 1995, along with again running nine of the currently vacant BBS routes, 2) to develop bird check lists for all units, and 3) to revise all current check lists over 15 years old, 4) to implement Forest Level point count monitoring in all Forests by 1995, 5) to initiate Special Project monitoring for management impacts on mature spruce/fir forests, 6) to conduct habitat relationships monitoring for various vegetation types, 7) to provide biologists training on monitoring techniques and study designs, and 8) to establish a regional data collection center (Roth 1994).

MONITORING GUIDELINES

The Forest Service, with the assistance of the Partners in Flight, has adopted a hierarchy of neotropical monitoring activities which incorporates three levels of avian monitoring (Manley et al. 1993).

Level One Monitoring

Level I monitoring consists of the most basic monitoring efforts which establish the presence, absence, and relative abundance of avian species and monitor basic avian population trends at a Forest level (Manley et al. 1993).

Level Two Monitoring

Level II monitoring investigates the relationship of population trends with land use practices and habitat characteristics (Manley et al. 1993). Level II monitoring focuses on acquisition of data on individual vegetative treatments and habitats, gathering information on habitat specific population trends, habitat relationships with species, and landscape effects on species.

Level Three Monitoring

Level III monitors species demographics, researching species survival rates and the reproductive success of populations (Manley et al. 1993). Level III monitoring delves into the cause-effect relationship between management activities and habitat quality with population viability rates. Level III monitoring obtains demographic data through the use of both constant effort mist netting and nest search and monitoring. This approach monitors population productivity and sizes, and post-fledgling and adult survivorship rates, providing data on large scale trends. The

nest search and monitoring approach measures productivity through nest success, and notes rates of predation and brood parasitism. This method tends to become rather labor intensive as at least 20 nests of each species must be located to establish species productivity (Manley et al. 1993).

NTMB RESEARCH ON THE MBNF

The MBNF has hosted a number of avian research projects performed by Forest Service employees, students and faculty affiliated with the University of Wyoming and various individual researchers. These pertinent studies are discussed in detail in Appendix 10. See also Appendix 1 for lists of studies.

Habitats Utilized by NTMB on the MBNF

One hundred and twenty-one neotropical migrants spend a portion of the year breeding, foraging, and nesting in portions of the MBNF (see Table 8.9). The geographical position of the MBNF may account for the presence of many of these neotropical visitors because it is at the end of three mountain ranges which extend south into Colorado, and it borders the Great Basin and northern Plains. The edges of the MBNF are bordered by grasslands and shrublands and are intersected throughout by significant canyons. Migratory species utilize a variety of habitats throughout the MBNF, including, but not limited to, riparian areas, low shrubs, willows thickets, aspen groves, shrublands, and open grasslands and forests of all ages (see Table 8.10).

While some species exhibit a certain degree of habitat flexibility, many other species display definite specialized habitat requirements (Finch 1991b). The identification and management of these habitats plays an key role in the conservation of neotropical species on the MBNF. See Appendix 10 for a discussion of NTMB by specific habitats on the Medicine Bow National Forest.

MANAGEMENT ACTIVITIES

Many management activities attempt to shorten the length of vegetative succession. Shorter vegetative rotation cycles often result in less complex vegetative structure, density, and composition, which in turn can lead to a reduction on both vegetative and avian species reductions (Beebe 1974; Thomas et al. 1975; Finch et al. 1993).

Timber Harvest

Strip and block clear cuts generally result in a reduction or loss of essential resources for interior forest species, and an increase in edge to interior ratios (Keller et al. 1992). Clearcutting disrupts species composition and population densities, adversely impacting interior dwelling forest species, while favoring edge and open field competitors (Smith 1980, Hutto, et al. 1993). Studies on the Kaibab National Forest revealed that northern goshawks experienced 75-80 percent lower occupancy rates where timber harvest occurred next to nesting areas and goshawk nest production was 94 percent lower in areas bordering harvested forest (Crocker-Bedford, 1990). These results have been disputed but not disproved. In some cases, clearcutting regimes may mimic natural disturbances, in that they create patterns across the landscape (Hutto et al. 1993). Future research should examine both detrimental and beneficial consequences of clearcutting, considering both short and long term effects on neotropical migrants. For a discussion of silvicultural effects on birds in the Rockies see Finch and Fletcher (1994).

Cavity nesting birds which are also neotropical migrants are listed in Table 8.11. These are species for which old growth forests with snags or diseased trees with cavities are important.

Livestock Grazing

Available water, shade, and favored vegetation often attract livestock, particularly cattle, to succulent riparian areas (Raley 1986; Bock et al. 1993). As cattle infiltrate the riparian areas they begin to impact the structure and density of riparian habitats by compacting the soil, removing plant materials, and reducing water infiltration (Bock et al. 1993). In addition, cattle often create tunnels through dense riparian willows and shrubs, which alters vegetative structure and density and enlarge the amount of grassland habitat found within the riparian area (Krueger, 1985; Krueger et al.; 1985, Finch 1986; Schulz et al. 1991). Livestock tunneling can increase the vegetative structural diversity, which can result in an increase in insect diversity, which in turn can attract certain birds (Krueger 1985). Some avian species utilize the cattle tunnels as passages for foraging and as channels for protection from aerial tunnels (Krueger 1985; Krueger et al. 1985).

TABLES FOR NEOTROPICAL MIGRATORY BIRDS

These tables list neotropical migratory birds which are known to occur on the Medicine Bow National Forest. A list of neotropical migratory birds stratified by mountain range is presented in Table 8.9.

Column headings are:

- SM - Sierra Madre Mountains
- SR - Medicine Bow Mountains (Snowy Range)
- SH - Sherman Mountains
- LP - Laramie Range
- TEC- Federal Status for Threatened, Endangered or Candidate species (See Faunal Species Appendix 9 for further information)
- SEN - Forest Service Region 2 Sensitive species
- MIS - Management Indicator Species (MBNF - 1985 Forest Plan)

- EC = Ecological indicator species
- RE = Recovery species
- NEO - Status of neotropical migrant:
  - A = breeds in the U.S.; winters south of U.S.
  - B = breeds and winters in U.S.
  - CONS - conservation priority. Birds which have a ranking of 4 and/or 5 on abundance, and/or threats to breeding ground (Partners in Flight Rankings).

A habitat model, based on habitat tables in DeGraaf (1991) is presented in Table 8.13. RIS Codes are: TSF = spruce-fir; TLP = lodgepole pine; TPP = ponderosa pine; TAA = aspen/hardwood; SHR = chaparral (shrublands); GRS = grasslands; RIP = riparian. This is a general model to illustrate the variety of cover types utilized by these neotropical migrants. It does not contain information as to age, structure or condition of vegetation preferred by these species. Detailed habitat assessment for each watershed is beyond the scope of this report.

Table 8.9 List of neotropical migratory birds of the Medicine Bow National Forest.

SM	SR	SH	LP	COMMON NAME	TEC	SEN	MIS	NEO	CONS
SM	SR	SH	LP	turkey vulture				B	
SM	SR	SH	LP	northern harrier				B	C
SM	SR	SH	LP	sharp-shinned hawk				B	C
SM	SR	SH	LP	Cooper's hawk				B	C
SM	SR	SH	LP	northern goshawk	C2	S	EC	B	C
SM	SR	SH	LP	Swainson's hawk				A	
SM	SR	SH	LP	red-tailed hawk				B	
SM	SR	SH	LP	ferruginous hawk	C2	S		B	C
SM	SR	SH	LP	golden eagle				B	
SM	SR	SH	LP	American kestrel				B	
SM	SR		LP	merlin		S		A	
SM	SR		LP	peregrine falcon	EN		RE	A	C
SM	SR	SH	LP	prairie falcon				B	C
SM	SR	SH	LP	killdeer				B	
	SR		LP	upland sandpiper		S		A	
SM	SR		LP	long-billed curlew	C3	S		A	C
SM	SR	SH	LP	mourning dove				B	
SM	SR			black-billed cuckoo				A	
			LP	yellow-billed cuckoo				A	C
			LP	flammulated owl		S		A	
SM	SR	SH		burrowing owl		S		A	C
SM	SR		LP	long-eared owl				B	
SM	SR		LP	short-eared owl				B	C
SM	SR	SH	LP	common nighthawk				A	
SM	SR	SH	LP	poor-will				B	
	SR			black swift		S		A	
			LP	chimney swift				A	
SM	SR		LP	white-throated swift				A	
			LP	black-chinned hummingbird				A	
SM	SR	SH	LP	broad-tailed hummingbird				A	
SM	SR	SH	LP	rufus hummingbird				A	
SM	SR	SH	LP	belted kingfisher				B	
SM	SR	SH	LP	Lewis' woodpecker		S	EC	B	C
SM	SR	SH	LP	yellow-bellied sapsucker			EC	B	
	SR	SH		red-naped sapsucker				B	C
SM	SR	SH	LP	Williamson's sapsucker				B	C
SM	SR	SH	LP	red-shafted flicker				B	
SM	SR	SH	LP	olive-sided flycatcher		S		A	C
SM	SR	SH	LP	western wood peewee				A	
SM			LP	alder flycatcher				A	

Table 8.9 continued

SM	SR	SH	LP	COMMON NAME	T&E	SENS	IND	NEO	CONS
SM	SR	SH	LP	willow flycatcher				A	C
			LP	least flycatcher				A	C
SM	SR	SH	LP	Hammond's flycatcher				A	C
SM	SR	SH	LP	dusky flycatcher				A	C
SM	SR	SH	LP	gray flycatcher				A	C
SM	SR	SH	LP	Say's phoebe				B	
	SR	SH	LP	cordilleran flycatcher				A	C
		SH	LP	Cassin's kingbird				A	
SM	SR	SH	LP	western kingbird				A	
	SR	SH	LP	eastern kingbird				A	
SM	SR	SH	LP	horned lark				B	
	SR	SH	LP	purple martin		S		A	
SM	SR	SH	LP	tree swallow				B	
SM	SR	SH	LP	violet-green swallow				A	
SM	SR	SH	LP	rough-winged swallow				A	
SM	SR	SH	LP	bank swallow				A	
SM	SR	SH	LP	cliff swallow				A	
SM	SR	SH	LP	barn swallow				A	
SM	SR	SH	LP	brown creeper				B	
SM	SR	SH	LP	rock wren				B	
SM	SR	SH	LP	house wren				A	
			LP	short-billed marsh wren				B	
SM	SR			long-billed marsh wren				B	C
SM	SR	SH	LP	ruby-crowned kinglet			EC	B	
SM	SR	SH	LP	blue-grey gnatcatcher				A	
SM	SR			western bluebird				B	
SM	SR	SH	LP	mountain bluebird				B	
SM	SR	SH	LP	Townsend's solitaire				B	
SM	SR	SH	LP	veery				A	
SM	SR	SH	LP	Swainson's thrush				A	
SM	SR	SH	LP	hermit thrush				B	
SM	SR	SH	LP	American robin				B	
SM	SR	SH	LP	gray catbird				A	
SM	SR	SH	LP	sage thrasher				B	C
SM	SR	SH	LP	cedar waxwing			EC	B	
SM	SR		LP	water pipit				B	
SM	SR	SH	LP	loggerhead shrike	C2	S		B	C
SM	SR	SH	LP	solitary vireo				A	C
SM	SR	SH	LP	warbling vireo				A	C
SM	SR	SH	LP	red-eyed vireo				A	
SM	SR	SH	LP	orange-crowned warbler				A	
			LP	Virginia's warbler				A	
SM	SR	SH	LP	yellow warbler			EC	A	C
		SH	LP	magnolia warbler				A	
SM	SR	SH	LP	yellow-rumped warbler				B	
SM	SR	SH	LP	Townsend's warbler				A	
			LP	blackpoll warbler				A	

Table 8.9 concluded

SM	SR	SH	LP	COMMON NAME	T&E	SENS	IND	NEO	CONS
			LP	black-and-white warbler				A	
SM	SR		LP	American redstart				A	
SM	SR	SH	LP	ovenbird				A	C
SM	SR	SH	LP	MacGillivary's warbler				A	C
SM	SR	SH	LP	common yellowthroat				A	C
SM	SR	SH	LP	Wilson's warbler				A	
SM	SR	SH	LP	yellow-breasted chat				A	
SM	SR	SH	LP	western tanager				A	
SM	SR	SH	LP	black-headed grosbeak				A	
SM	SR	SH	LP	Lazuli bunting				A	
SM	SR	SH	LP	green-tailed towhee				A	C
SM	SR	SH	LP	rufous-sided towhee				B	
SM	SR	SH	LP	chipping sparrow				A	
SM	SR	SH	LP	clay-colored sparrow				A	C
SM	SR		LP	Brewer's sparrow				A	
SM	SR			sage sparrow				B	C
SM	SR	SH	LP	vesper sparrow				B	
SM	SR	SH	LP	lark sparrow				A	
SM	SR	SH	LP	lark bunting				A	C
SM	SR	SH	LP	fox sparrow		S		B	
SM	SR	SH	LP	Lincoln's sparrow				A	
SM	SR	SH	LP	song sparrow				B	
SM	SR	SH	LP	dark-eyed junco				B	
SM	SR	SH	LP	white-crowned sparrow			EC	B	
SM	SR	SH	LP	McCown's longspur				B	C
SM	SR	SH	LP	red-winged blackbird				B	
SM	SR	SH	LP	western meadowlark				B	
SM	SR			yellow-headed blackbird				A	C
SM	SR	SH	LP	Brewer's blackbird				B	
SM	SR	SH	LP	brown-headed cowbird				B	
SM	SR		LP	northern oriole				A	
SM	SR	SH	LP	Cassin's finch				B	
SM	SR	SH	LP	pine siskin				B	
SM	SR	SH	LP	American goldfinch				B	

Table 8.10 Habitat matrix for neotropical migratory birds of concern on the Medicine Bow National Forest.

SM	SR	SH	LP	COMMON NAME	TEC	SEN	MIS	NEO	TSF	TLP	TPP	TAA	SHR	GRS	RIP
SM	SR	SH	LP	northern goshawk	C2	S	EC	B	X	X	X	X			
SM	SR	SH	LP	Williamson's sapsucker				B	X	X	X	X			
SM	SR	SH	LP	olive-sided flycatcher		S		A	X	X	X	X			
SM	SR	SH	LP	ovenbird				A	X	X	X	X			
SM	SR	SH	LP	Hammond's flycatcher				A	X	X	X	X			
SM	SR	SH	LP	sharp-shinned hawk				B	X	X	X	X	X		
SM	SR	SH	LP	Cooper's hawk				B	X	X	X	X	X		
SM	SR		LP	peregrine falcon	EN		RE	A	X	X	X	X	X		
SM	SR	SH	LP	dusky flycatcher				A	X	X	X	X	X		
	SR	SH	LP	cordilleran flycatcher				A	X	X	X	X	X		
SM	SR	SH	LP	solitary vireo				A	X	X	X	X	X		
SM	SR	SH	LP	warbling vireo				A	X	X	X	X	X		
SM	SR	SH	LP	yellow warbler			EC	A	X	X	X	X	X		
SM	SR	SH	LP	MacGillivary's warbler				A	X	X	X	X	X		
SM	SR	SH		common yellowthroat				A	X	X	X	X	X		
SM	SR	SH	LP	Lewis' woodpecker		S	EC	B	X		X	X			
SM	SR	SH	LP	prairie falcon				B			X	X	X		
SM	SR		LP	short-eared owl				B			X	X	X		
SM	SR	SH	LP	loggerhead shrike	C2	S		B			X	X	X		
SM	SR	SH	LP	green-tailed towhee				A			X	X	X		
SM	SR	SH	LP	gray flycatcher				A			X		X		
			LP	least flycatcher				A			X			X	
SM	SR	SH	LP	willow flycatcher				A			X	X			X
SM	SR	SH	LP	clay-colored sparrow				A						X	
	SR	SH		burrowing owl		S		A						X	
SM	SR	SH	LP	ferruginous hawk	C2	S		B						X	
SM	SR	SH	LP	lark bunting				A						X	
SM	SR	SH	LP	McCown's longspur				B						X	X
SM	SR			yellow-headed blackbird				A						X	X
SM	SR	SH	LP	northern harrier				B						X	X
SM	SR		LP	long-billed curlew	C3	S		A						X	X
			LP	yellow-billed cuckoo				A						X	X
SM	SR			long-billed marsh wren				B							X
SM	SR	SH	LP	sage thrasher				B							X
	SR	SH		red-naped sapsucker				B							X
SM	SR			sage sparrow				B							X

In some cases, alterations caused by grazing may cause a decline or replacement of shrub-nesting species and an increase in species that require no particular vertical vegetation structure (Schultz et al. 1991). Avian species which prefer areas with little ground cover and aerial foragers who prefer open habitats, such as the mountain bluebird, Lewis woodpecker, American robin, and killdeer, may be attracted to areas trampled by livestock (Krueger 1985). On the other hand, livestock tunnelling may adversely affect some neotropical specialists such as the common yellowthroat, Wilson's warbler, and Lincoln's sparrow and other species that require very dense heavy shrubs or herbaceous ground cover for nesting and foraging (Krueger 1985; Schulz et al. 1991; Bock et al. 1993).

Foresight and cooperative planning by forest and livestock managers may reduce the impact of grazing on fragile riparian areas. Drift fences placed at key positions along riparian areas can provide critical protection to sensitive habitats, minimizing the amount of habitat grazed and trampled (Bock et al. 1993). Alternative water sources, in the form of stock tanks and stock ponds, may encourage livestock to disperse more uniformly throughout a grazing area instead of concentrating heavily along the riparian habitats (Bass 1995).

Snag reduction and removal

Many neotropical species utilize snags (Table 8.11) for nesting, hunting, feeding, roosting, lounging, and food storage (Scott and Crouch 1980). Certain forest management practices can result in reduced numbers, or even a total loss, of the snags and dead standing trees which provide nesting sites for avian cavity dwellers (Thomas et al. 1975). Even-aged management practices and the shortening of tree rotation length tend to produce less diverse forests with fewer trees mature enough to have reached the state of decay preferred by hole nesters (Beebe 1975). Often the trees utilized by cavity dwelling species are removed by salvage cuts and thinning, or though selective cutting and firewood cutting (Diem and Zevloff 1980; Beebe 1974). Forest Service signs on snags may not always provide adequate protection. In the Red Feather Lakes District, Forest Service employees tacked signs on ten snags; by the following year all ten snags had been removed by firewood cutters (Scott and Crouch 1980). Similarly, in the Boulder District of the Arapaho-Roosevelt National Forest, 100 signs were posted on snags; two years later all but three of the snags had been cut into firewood (Scott and Crouch 1980). New snag retention policies such as leaving snags in groups (snag farms) along edges of clearcuts to reduce snag loss from blowdown, or creating snags by tree girdling, have helped. Snag habitat is still a concern.

Table 8.11 Cavity-nesting neotropical migratory birds of the Medicine Bow National Forest.

MOUNTAIN RANGE				COMMON NAME	TEC	SEN	MIS	NEO	CONS
SM	SR	SH	LP	turkey vulture				B	
SM	SR	SH	LP	American kestrel				B	
SM	SR		LP	merlin		S		A	
SM	SR		LP	peregrine falcon	EN		RE	A	C
			LP	flammulated owl		S		A	
SM	SR			boreal owl	C	S		A	C
			LP	chimney swift				A	
SM	SR	SH	LP	Lewis' woodpecker		S	EC	B	C
SM	SR	SH	LP	yellow-bellied sapsucker			EC	B	
SM	SR	SH	LP	Williamson's sapsucker				B	C
	SR	SH	LP	cordilleran flycatcher				A	C
	SR	SH	LP	purple martin				A	
SM	SR	SH	LP	tree swallow				B	
SM	SR	SH	LP	violet-green swallow				A	
SM	SR	SH	LP	brown creeper				B	
SM	SR	SH	LP	house wren				A	
SM	SR	SH	LP	western bluebird				B	
SM	SR	SH	LP	mountain bluebird				B	

Scott et al. 1977. Cavity-nesting Birds of North American Forests. Agriculture Handbook 511 USDA Forest Service Washington, D.C.

Old Growth Retention

A number of avian species seem to rely on or at least prefer old growth forest (Kaufman et al. 1992; Romme et al. 1992). The number of old growth patches and the pattern of old growth distribution across a landscape will determine, or in some cases limit, the presence of old growth dependent species (Kaufman et al. 1992). The dissection or complete loss of large blocks of old growth forest may have a negative impact on certain avian species (Thomas et al. 1975), particularly interior dependent species. A decrease in forest canopy closure may result in increased nesting failures, as some species, like the northern goshawk, require large patches of dense forest with 76 to 94 percent canopy closure for breeding and nesting (Crocker-Bedford 1990; Forest News, 1991; Ward et al. 1992)). Connecting linkages between fragmented island patches and the undisturbed forest body may ease the pressure of fragmentation (Robbins 1979).

Recreation

Effects of human disturbance from recreational activities have not been assessed on the MBNF. General effects of recreation on birds of prey are reviewed by Knight and Skagen (1988). Some species, such as the northern goshawk, may abandon their nests if disturbed by human activities during the critical nesting times in late March to early June (Sisson et al. 1978). General interactions between wildlife and recreationists are discussed in Knight and Gutzwiller (1995).

Other Activities

Other activities on the forest may pose latent threats for neotropical migrant habitats. Potentially intrusive activities include mining, irrigation, fire suppression, and herbicide and pesticide usage (Hutto et al. 1993). Further research is needed to determine to what extent multiple human activities in various avian habitats at differing times of the year impact specific migratory species.

EFFECTS OF FOREST FRAGMENTATION

Most studies on NTMB habitat relationships have been done in eastern forests which have been fragmented into habitat islands in a matrix of agriculture or urbanization. The fragmentation of Rocky Mountain Forests is primarily that of age class, structure, and to some extent change of
species. While age fragmentation in western forests may not be as extreme as type conversion of eastern forests, there may be effects on habitats which are important to bird survival and reproduction. For example, clearcuts in early successional stages, located near natural openings, may provide a path into

formerly unbroken interior forest habitat, effectively reducing patch size of interior forest and changing predator-prey relationships or foraging opportunities..

Many long-term studies have revealed declines or local extinctions in certain avian species inhabiting dissected forests, as forest fragmentation reduces the size and the quality of interior forest habitat (Temple et al. 1988; Finch 1991b). In most cases, more forest interior species, including a number of neotropical migrants, reside in large blocks of forest than in small pieces of forest (Finch 1991b). These species decline or disappear if the large forest blocks become fragmented (Finch 1991b; Rolstad 1991). Compared to unfragmented patches, island habitats created by forest fragmentation tend to display higher avian extinction rates and lower immigration rates, as well as a noted absence of forest interior species (Finch 1991b).

Many species have minimum habitat size requirements (Samson 1980; Rolstad 1991). If habitat patch sizes decrease below a specific threshold size, some species may experience local declines or extinctions (Rolstad 1991). Creating habitat diversity by subdividing large tracts of land may result in loss of these size-dependent species (Samson 1980). Research on the MBNF observed a complete absence of brown creepers and a reduced number of hermit thrushes in fragmented stands as compared to uncut stands (Keller et al. 1992). The need to retain large contiguous tracts of undisturbed forest to ensure quality habitat for interior dependent avian species is suggested by these results (Robbins 1979).

NTMB AND MANAGEMENT INDICATOR SPECIES (MIS)

Management indicator species are identified in the 1985 Forest Plan. These single species were chosen as items to monitor to track both population trend and habitat condition for specific habitats. Nine NTMB species are also MIS species (bald eagle, northern goshawk, merlin, Lewis' woodpecker, yellow-bellied sapsucker, cedar waxwing, loggerhead shrike, yellow warbler, and white-crowned sparrow). Bale eagle is an endangered species while northern goshawk, merlin and Lewis' woodpecker are former Candidate 2 species and/or on the R-2 Sensitive species lists. Only bald eagle and northern goshawk have received attention for population and habitat monitoring. The choice of MIS and implementation of monitoring to determine population trends and habitat condition or relationships needs attention during Forest Plan Revision.

BIG GAME CONSIDERATIONS

LARGE HERBIVORES

The history of wildlife exploitation and conservation on the Medicine Bow National Forest closely follows that of other states in the western United States and provinces of Canada.

Market hunting of big game severely depleted populations of deer, elk, antelope, and bighorn sheep in the Laramie Plains and nearby mountains following completion of the Union Pacific Railroad in 1867. Reintroductions of elk and bighorn sheep occurred in the first few decades of the 20th century. See the discussion and historical chronologies in Chapter 4. Population estimates of elk, deer, antelope, and bighorn sheep are presented in Table 8.12.

Populations of game animals and birds have fluctuated widely since the initiation of market hunting in the mid-1800s. Wildlife Conservation efforts dating from the turn of the century evolved into the game management movement of the 1920s and 30s. Sustained annual crops of wild game for recreational use is a major objective of game management.

Big game hunting on the forest continues to be extremely important locally, regionally and nationally. The economic impact to local communities associated with hunting is very significant. Wyoming Game and Fish department officials in the Big Horn Mountains of Northern Wyoming have estimated that approximately $80 is generated to the local community by each elk hunter daily.

Generally conservative management strategies and mild winters have resulted in near record big game populations in much of the West. However, big game managers have recently begun to observe disturbing trends including over harvest of older age class males. There are more complicated restrictions and permit systems and a growing concern because of elk leaving public lands before, or early into, the fall hunting season.

Big game areas and migration routes are shown in Figures 8.4 (mule deer), 8.5 (elk), 8.6 (antelope), and 8.7 (mule deer). These maps were constructed by District Wildlife Biologists from Wyoming Game and Fish information. Wyoimng Game and Fish herd unit management area boundaries are different for various big game species and do not correspond with each of the mountain range units of the Medicine Bow National Forest. To make these maps and Tables 8.12 and 8.13 Wyoming Game and Fish herd units which included the Medicine Bow

BIG GAME CONSIDERATIONS

LARGE HERBIVORES

The history of wildlife exploitation and conservation on the Medicine Bow National Forest closely follows that of other states in the western United States and provinces of Canada.

Market hunting of big game severely depleted populations of deer, elk, antelope, and bighorn sheep in the Laramie Plains and nearby mountains following completion of the Union Pacific Railroad in 1867. Reintroductions of elk and bighorn sheep occurred in the first few decades of the 20th century. See the discussion and historical chronologies in Chapter 4. Population estimates of elk, deer, antelope, and bighorn sheep are presented in Table 8.12.

Populations of game animals and birds have fluctuated widely since the initiation of market hunting in the mid-1800s. Wildlife Conservation efforts dating from the turn of the century evolved into the game management movement of the 1920s and 30s. Sustained annual crops of wild game for recreational use is a major objective of game management.

Big game hunting on the forest continues to be extremely important locally, regionally and nationally. The economic impact to local communities associated with hunting is very significant. Wyoming Game and Fish department officials in the Big Horn Mountains of Northern Wyoming have estimated that approximately $80 is generated to the local community by each elk hunter daily.

Generally conservative management strategies and mild winters have resulted in near record big game populations in much of the West. However, big game managers have recently begun to observe disturbing trends including over harvest of older age class males. There are more complicated restrictions and permit systems and a growing concern because of elk leaving public lands before, or early into, the fall hunting season.

Big game areas and migration routes are shown in Figures 8.4 (mule deer), 8.5 (elk), 8.6 (antelope), and 8.7 (mule deer). These maps were constructed by District Wildlife Biologists from Wyoming Game and Fish information. Wyoimng Game and Fish herd unit management area boundaries are different for various big game species and do not correspond with each of the mountain range units of the Medicine Bow National Forest. To make these maps and Tables 8.12 and 8.13 Wyoming Game and Fish herd units which included the Medicine Bow

Table 8.12 continued

BIGHORN SHEEP HERD UNIT

Year	Laramie Pk.	Encamp. River	Douglas Creek
1984	300	102	158
1985	217	93	161
1986	140	52	125
1987	205	54	139
1988	207	50	143
1989	232	62	140
1990	223	58	129
1991	218	61	129
1992	188	50	109
1993	173	61	108

Table 8.13 Population and harvest data for game animals, small mammals, and birds 1993 (Wyoming Game and Fish Department Database)

ELK POPULATION ESTIMATES

Herd Unit	Pop. Est. 93	Pop. Obj	Hunters	Harvest	Success	Rec. Days
Sierra Madre	5000	4200	3884	964	26%	17409
Iron Mtn.	173	500	290	126	43%	N/A
Laramie Peak	3140	2550	1119	497	44%	N/A
Snowy Range	6888	4900	2052	1170	27%	28562

MOOSE POPULATION ESTIMATES

Herd						
Snowy Range	100	0	4*	0		

*objective

BIGHORN SHEEP POPULATION ESTIMATES

Herd Unit						
Laramie Peak	173	500	6	2	27%	N/A
Snowy Range	108	350	8	4	47%	82
Sierra Madre	61	200	1	1	80%	12

Table 8.13 concluded.

MULE DEER POPULATION ESTIMATES

Herd Unit	Pop. Est. 93	Pop. Obj	Hunters	Harvest	Success	Rec. Days	
Laramie Peak	34297	42000	7271	4363	60%		
Iron Mnt.	14725	15000	1754	1142	65%	N/A	
Snowy Range	27649	35000	7055	2565	36%		
Sierra Madre		13076	18700	4546	2633	56%	12930

BLUE GROUSE POPULATION ESTIMATES

Area	#Hunters	Rec. Days	Harvest
Laramie Peak	418	1433	299
Snowy Range	578	2076	612
Sierra Madre	536	1918	611

SNOW SHOE HARE POPULATION ESTIMATES

Area	#Hunters	Rec. Days	Harvest
Laramie Peak	15	100	61
Snowy Range	74	355	149
Sierra Madre	26	252	208

National Forest were combined to give area totals which include areas outside of National Forest boundaries. Table 8.13 summarizes big game population statistics and harvest data for the years 1975 through 1993. Harvest data is from the Wyoming Game and Fish Department, 1995.

Roads, blocked up NFS ownership, and winter range on publically owned land near or adjacent to NFS land in the Sierra Madre and Medicine Bow Mountains provides good access for big game hunters. Hiding cover for elk and deer is a management concern in these mountain ranges. In contrast, in the Laramie Mountains, private land prevents access to much of the National Forest and much of the winter range is on private land. Distribution and population of both animals and hunters in the Laramie Mountains need to be evaluated with regard to habitat use and condition (Robinson 1995).

Moose are dispersing onto the MBNF from herd-transplants of the mid-1970s in northern Colorado. There are no historic records of moose on the MBNF. Significant immigration from herds in the northern Rocky Mountains is higly unlikely. Radio-collard moose have been located up to 25 miles north of the Colorado-Wyoming line. Moose sightings have occured in all areas of the MBNF, as far north as Arlington, in the Laramie Mountains and the Sherman Mountains. Most moose sightings are in the Sierra Madre and Snowy Range. It is not known if increased sightings are due to an increase in resident population size, from migration of additional individuals from Colorado or repeated sightings of the same animals.

Current moose population in the Snowy Range is estimated to be between 80-100 individuals. In 1986 the Wyoming Game and Fish Department established Snowy Range Moose Hunt Area 38 but it is currently closed to hunting until a management plan can be devloped. Current herd unit objective is set at 100 animals (Wyoming Game and Fish 1992). Eight moose were illegally killed on the MBNF during deer and elk hunting season in 1995.

Willow-dominated riparian habitats are key winter range for moose. Past use in these willow communities has been considered light (Harper personal communication). Current research on moose is being done by Colescott (1994) and Zimmerman (1995).

LARGE PREDATORS

Mountain lions and black bears are large predators which are hunted mostly in the Medicine Bow Mountains and Laramie Mountains. Black bears are hunted using bear-baiting techniques and mountain lions are usually hunted with dogs.

Population sizes are not known for certain. Harvest levels from 1990-1994 are in Table 8.14.

In 1994 a cooperative study of black bear populations in the Medicine Bow Mountains was undertaken between Wyoming Game and Fish and the Coop Research Unit at the University of Wyoming to determine bear population size, age, and sex characteristics and selected life history traits. Ron Grogan is currently doing the field research for a Masters program. Three study areas (Rock Creek-Medicine Bow River area; Keystone-Albany area and French Creek-Brush Creek area) were sampled. Preliminary information indicates that the low density black bear population in the Medicine Bow Mountains is composed of small size individuals. Food type and availablity is a possible reason, because the ecosystem does not contain high-fat foods such as acorns and pine nuts (Grogan 1995).

Table 8.14 Black bear and mountain lion harvest 1990-1994. Data courtesy of Wyoming Game and Fish Department.

BLACK BEAR HARVEST

Year	Sierra M.	Lar. Mts.	Med B. Mts	Total
1990	7	11	10	28
1991	7	8	11	26
1992	11	11	14**	36
1993	7	8*	7***	22
1994	6	6**	6	18
TOTAL	**38**	**44**	**48**	**130**

* Includes one illegal harvest and one damage harvest.
** Inclues one damage harvest.
*** Includes one illegal harvest.

MOUNTAIN LION HARVEST

Year	Sierra M.	Lar. Mts.[1]	Med B Mts.	Total
1990	2	21	9	32
1991	4	24*	10	38
1992	2	20	7	29
1993	2	18**	9**	28
1994	3	24	10	37
TOTAL	**13**	**107**	**45**	**164**

* Includes one accidental kill.
** Includes one illegal harvest
[1] Hunt areas 5 and 6 which together include the entire Laramie Range and Sherman Mountains from the Colorado State line to south of Casper.

LITERATURE CITED

Alexander, R.R.; Troendle, C.A; Kaufmann, M.R; Sheppard, W.D.; Crouch, G.L; Watkins, R.K. 1985. The Fraser Experimental Forest, Colorado: research program and unpublished research 1937-1985. U.S. Forest Service General Technical Report RM-118.

Bass, J. 1995. Where the deer and the antelope play. Wyoming Wildlife, Feb. 1995: 40-43.

Baxter, G.T. 1952. The relation of temperatures to the altitudinal distribution of frogs and toads in southeastern Wyoming. PhD Dissertation. University of Michigan. Ann Arbor, MI.

Baxter, G.; Stone, M. 1980. Amphibians and reptiles of Wyoming. Wyoming Game and Fish Department, Bulletin No. 16. Cheyenne, Wyoming.

Beebe, S.B. 1974. Relationships between insectivorous hole-nesting birds and forest management. Graduate Thesis, Yale University of Forestry and Environmental Studies.

Behnke, R.J. 1992. Native trout of Western North America. American Fisheries Society Monograph 6.

Behnke, R.J.; Zarn, M. 1976. Biology and management of threatened and endangered western trout. U.S. Forest Service Gen. Tech. Rep. RM-28.

Binns, N.A. 1977. Present status of indigenous populations of cutthroat trout, *Salmo clarki*, in southwest Wyoming. Wyoming Game and Fish Department, Fishery Technical Bulletin 2. Cheyenne.

Biodiversity Legal Foundation. 1993. Letter to Forest Supervisor, Jerry Schmidt, Dec. 26, 1993.

Blake, I.H. 1945. An ecological reconaissance in the Medicine Bow Mountains. Ecological Monographs 15: 207-242.

Bock, C.E.; Saab, V.A.; Rich, T.D.; Dobkin, D.S. 1993. Effects of livestock grazing on neotropical migratory landbirds in Western North America. Gen Tech Rep RM-229. U.S. Department of Agriculture, Forest Service. Fort Collins, CO.

Bozek, M.A.; Rahel, F.J. 1991. Comparison of streamside visual counts to electrofishing estimates of Colorado River cutthroat trout fry and adults. North American Journal of Fisheries 113: 8-42.

Brown, L.N. 1967. Ecological distribution of six species of shrews and comparison of sampling methods in the central Rocky Mountains. Journal of Mammalogy. 48: 617-623.

Brown, M.; Dinsmore, J.J. 1986. Implications of marsh size and isolation for marsh bird management. J. Wildl. Manage, 50: 392-397.

Campbell, J. P. 1970. Life History of *Bufo boreas boreas* in the Colorado Front Range. PhD dissertation. University of Colorado, Boulder CO.

Capen, D. E. 1977. The impact of pesticides on the white-faced ibis. PhD Dissertation. Utah State University, Logan, UT. 85pp.

Cary, C. 1993. Hypothesis concerning the causes of disappearance of boreal toads from the mountains of Colorado. Conservation Biology 7: 355-362.

Clark, T. W.; Stromberg, M.R. 1987. Mammals in Wyoming. University of Kansas Museum of Natural History. 314 pp.

Colborn, L.G. 1966. The limnology and cutthroat trout fishery of Trappers Laek, Colorado. Department of Game, Fish and Park, Denver, CO. Fisheries Research Division Report 9.

Colescott, J.H. 1994. Winter forage selection and plant response; a dynamic relationship between Shiras moose (*Alces alces shirasii*) and riparian willow (*Salix* spp.). Master's Thesis (In progress). University of Wyoming, Laramie, WY.

Conder, A.; Jesperson, D. 1986. Colorado River cutthroat trout spawning and incubation habitat summary. Wyoming Game and Fish Administrative Report IF-5085-13-6602.

Cope, E.D. 1871. Report on the reptiles and fishes obtained by the naturalists of the expedition, pp. 432-442. In: F.V. Hayden, Second (fourth) annual report, U.S. Geological Survey of Wyoming, and portions of contiguous territories.

Corn, P. S.; Vertucci, F.A. 1992. Descriptive risk assessment of the effects of acidic deposition on Rocky Mountain amphibians. J. Herpetology 26: 361-369.

Corn, P. S.; Stolzenburg, W.; Bury, R.B. 1989. Acid precipitation studies in Colorado and Wyoming: interim report of surveys of montane amphibians and water chemistry. U.S. Fish and Wildlife Service Biological Report 80 (40.26). 56 pp.

Crocker-Bedford, D.C. 1990. Goshawk reproduction and forest management. Wildlife Society Bulletin 18: 262-269.

Crowe, D.M. 1986. Furbearers of Wyoming. Wyoming Game and Fish Department, Cheyenne, Wyoming. 74pp.

Davis, C.P. 1995. Letter from USFWS to Medicine Bow National Forest regarding Threatened, Endangered and Candidate Species to be expected on the Medicine Bow National Forest. Feb. 24, 1995

Degraaf,R.M.; Scott, V.E.; Hamre, R.H.; Ernst, L.; Anderson, S.H. 1991. Forest and Rangeland Birds of the United States. Agriculture Handbook 688 Washington, D.C.(Used for habitat matrix in Table 8.10)

Diem, K.L; Zevloff, N. 1980. Ponderosa pine bird communities. IN: Workshop for Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Feb. 11-14, 1980. U.S. Department of Agriculture, Forest Service, Gen Tech Rep INT-86, Rocky Mountain Forest and Range Experimental Station, Ogden, UT.

Duffy, S. G. 1976. Survey of potential habitat for American peregrine falcons on the Laramie Ranger District. Unpublished. University of Wyoming. Laramie, WY.

Eaglin, G.S. 1991. Influence of logging and road construction on trout streams, Medicine Bow National Forest. Specialist Report.

Federal Register. August 20, 1994. Endangered and Threatened Wildlife and Plants. 50CFR 17.11 and 17.12. U.S. Government Printing Office 380-789/20165.

Fertig, W. 1994a. Wyoming rare plant field guide. The Nature Conservancy. Wyoming Natural Diversity Database Laramie, WY

Fertig, W. 1994b. Wyoming candidate, threatened, endangered, and sensitive plants. 1994 WY Rare Plant Conference, Riverton, WY. Wyoming Natural Diversity Database, 1604 Grand Ave., Laramie WY.

Finch, D.M. 1986. Similarities in riparian bird communities among elevational zones in Southeastern Wyoming. Proceedings Wyoming 1986 Water and Streamside Zone Conference, Casper, WY, Apr. 28-30, 1986.

Finch, D.M. 1991a. Neotropical migratory bird research at the Rocky Mountain Forest and Range Experimental Station. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. Electronic mail April 29, 1991.

Finch, D.M. 1991b. Population ecology, habitat requirements, and conservation of neotropical migratory birds. Gen Tech Rep RM-205. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station.

Finch, D.M. 1992. Threatened, endangered, and vulnerable species of terrestrial vertebrates in the Rocky Mountain Region. General Technical Report RM-215. USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Finch, D.M.; Fletcher, R. 1994. Silvicultural effects on birds in the Rockies. USDA Forestry Research West April 1994: 6-11.

Finch, D.M.; Stangle, P.S. (eds.). 1992. The status and management of neotropical migratory birds. USDA Forest Service General Technical Report RM-229. Fort Collins, CO.

Finch, D.M.; Block, W.M.; Fletcher, R.A.; Fager, L.F. 1993. Integrating neotropical migratory birds into forest service plans for ecosystem management. Trans. 58th Wildlife and Natural Resources Conference, 417-421.

Forest News. 1991. Conservationists call for immediate moratorium on old-growth logging in southwest to save goshawk. Forest Watch, June 1991, 4-5.

Fowden, M. 1995. Personal communication.

Garber, C. 1992. A summary of records of wood frogs and boreal toads on the Medicine Bow National Forest in Wyoming. Wyoming Natural Diversity Database, Laramie, WY

Garber, C. S. 1994. A status survey for spotted frog, woods frogs, and boreal toad in the mountains of southern and eastern Wyoming. Wyoming Natural Diversity Database Laramie, WY 137 pp.

Garber, C.S. 1995. An addendum (#1) to: A status survey for spotted frog, woods frogs, and boreal toad in the mountains of southern and eastern Wyoming. Wyoming Natural Diversity Database, Laramie, WY.

Garber, C. S.; Wallen, R.L.; Duffy, K.E. 1991. Distribution of boreal owl observation records in Wyoming. J. Raptor Res. 25(4): 120-122.

Griffith, J.S. 1988. Review of competition between cutthroat trout and other salmonids. American Fisheries Society Symposium:134-140.

Grogan, R. 1995. Personal communication regarding bear research.

Grubb, T. G.; Kennedy, C.E. 1982. Bald eagle winter habitat on the Southwestern National Forests. Research paper RM-237. 13pp. U.S. Forest Service. Fort Collins, Colorado.

Grubb, T. G.; Nagiller, S.J.;Eakle, W.L. Goodwin, G.A. 1989. Winter roosting patterns of bald eagles *(Haliaeetus leucocephalus)* in North-Central Arizona. The Southwest Naturalist 34(4):453-459.

Haas, S. 1993. The northern Goshawk: Status of our knowledge and the effects of timber management. Specialist Report. Medicine Bow National Forest. Laramie, WY.

Hammerson, G. A. 1986. Amphibians and reptiles in Colorado. Second Printing. Colorado Division of Wildlife publication number DOW-M-I-3-86. 136 pp.

Harper, J. 1994. Biological Evaluation for White Swan-Holmes timber sale. Laramie Ranger District. Medicine Bow National Forest, Laramie, WY.

Harper, J. Personal communication. USFS - Medicine Bow National Forest - Laramie District biologist.

Hayward, G. Personal communication. Department of Zoology and Physiology, University of Wyoming.

Hayward, G.D. 1994. Conservation status of boreal owls in the United States. Pages 139-147 IN: Hayward, G.D.; Verner, J. (eds.) Flammulated, boreal and great grey owls in the Untied States: A technical conservation assessment. U.S. Forest Service General Technical Report RM-253. Fort Collins, CO.

Hayward, G.D.; Hayward, P.H. 1993. Boreal owl. IN: Poole, A.; Stettenheim, P.; Gill, F. (eds.). Birds of North America. No. 63. Philadelphia Academy of NAtiral Sciences, Washington, DC..

Hayward, G.D.; Hayward, P.H. 1995. Relative abundance and habitat associations of small mammals in Chamberlain Basin, central Idaho. Northwest Science 69: 114-125.

Hayward, G.D.; Rosentreter, R. 1994. Lichen as nesting material for northern flying squirrels in the northern Rocky Mountains. Journal of Mammology 75: 663-673.

Hayward, G.D.; Hayward, P.H.; Garton, E.O. 1987. Movements and home range use by boreal owls in central Idaho. In: Nero R.W.;Knapton,C.R.; Hamre, R.J. eds. Biology and conservation of northern forest owls: Symposium Proceedings. Gen. Tech. Report RM-142. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 309p.

Hayward, G.D.; Hayward, P.H.; Garton, E.O. 1993. Ecology of boreal owls in the northern Rocky Mountains, USA Wildlife Monographs.

Hayward, G.D.; Verner, J. 1994. Flammulated, boreal and great gray owls in the United States: A Technical Conservation Assessment. USDA Forest Service General Technical Report RM-253. Fort Collins, CO.

Henry, H. personal communication. Technician for pine marten research, Rocky Mountain Station Laboratory, Laramie, WY.

Herger, L.G. 1993. Assessment of the basin-wide habitat inventory technique relative to Colorado River cutthroat trout. Master's Thesis University of Wyoming, Laramie, WY.

Hipple, D. 1986. Summary of washouts at Deadman Creek, First Creek, Second Creek, and Rose Creek on Stage II Little Snake River Diversion pipeline. Medicine Bow National Forest Report. Laramie, WY.

Hutto, R.L.; Hejl, S.J.; Preston, C.R.; Finch, D.M. 1993. Effects of silvicultural treatments on forest birds in the Rocky Mountains: Implications and Management Recommendations. Gen Tech Rep RM-229. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Jankovsky-Jones, M; Jones, G.P.; Fertig, W. 1995. Ecological evaluatioons for potential Research Natural areas (Moraine Ponds report). Wyoming Natural Diversity Database. Laramie, WY.

Jesperson, D.M. 1979. Instream flow determinations and impact evaluation of water diversions on the Colorado River cutthroat trout and brook trout in the North Fork Drainage, Forest Service Report, Medicine Bow National Forest, Laramie Wyoming.

Jesperson, D.M. 1980. Instream flow determinations for streams affected by stage I and II of the City of Cheyenne water development project in the Douglas Creek Drainage and supplemental flow recommendations in the North Fork of the Little Snake River Drainage, Forest Service Report, Medicine Bow National Forest, Laramie, Wyoming.

Jesperson, D.M. 1981. A study of the effects of water diversions on the Colorado River cutthroat trout (*Salmo clarki pleuriticus*) in the drainage of the North Fork of the Little Snake River in Wyoming. Master's Thesis. University of Wyoming.

Johnsgard, P. A. 1986. Birds of the Rocky Mountains. Colorado Associated University Press, Boulder, CO. 504pp.

Jones, S. 1979. Habitat management series for unique or endangered species; the accipiters: goshawk, cooper's hawk, sharp-shinned. U.S. Department of the Interior. Report No. 17. 51pp. Bureau of Land Management. Denver, Colorado.

Jordon, D.S. 1891. Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined. U.S. Fish Comm. Bull. 9:1-40.

Kaufman, M.R; Moir, W.H; Covington, W.W. 1992. Old-growth forests: what do we know about their ecology and management in the Southwest and Rocky Mountain Regions? In: Old-Growth Forests in the Southwest and Rocky Mountain Regions - Proceedings of a Workshop. March 9-13, Portal, Arizona. U.S. Department of Agriculture, Forest Service, Gen Tech Rep RM-213, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colo., 1-11.

Keller, M.E. 1987. The effect of forest fragmentation on birds in spruce-fir old growth. PhD Dissertation. University of Wyoming. Laramie, WY.

Keller, M.E.; Anderson, S.H. 1992. Avian use of habitat configurations created by forest cutting in Southeastern Wyoming. The Condor 94: 55-65.

Klott, J.H.; Lindzey, F.J. 1990. Brood habitats of sympatric sage grouse and sharp-tailed grouse in Wyoming. J. Wildlife Management 54:84-88.

Knight, R.L.; Skagen, S.K. 1988. Effects of recreational disturbance on birds of prey: a review. Pages 355-359 IN: Glinski, R.L. et al. eds. Proceedings of the southwest Management Symposium and Workshop. National Wildlife Federation, Washington, D.C

Knight, R.L.; Gutzwiller, K.J. 1995. Wildlife and Recreationists. Island Press, Colvelo, CA.

Krueger, H.O. 1985. Avian response to mountainous shrub-willow riparian systems in Southeastern Wyoming. PhD Dissertation, University of Wyoming, Laramie, WY.

Krueger, H.O.; Anderson, S.H. 1985. The use of cattle as a management tool for wildlife in shrub-willow riparian systems. Paper presented at symposium on riparian ecosystems and their management: Reconciling conflicting uses, Tucson, AZ, Apr. 16-18, 1985.

Leaf, C.F. 1970. Sediment yields from central Colorado snow zone. American Society of Civil Engineers, Hydraulic Division Journal 96: 87-93.

Linder, K. A. 1994. Habitat utilization and behavior of nesting Lewis' woodpeckers (*Melanerpes lewis*) in the Laramie Range, southeastern Wyomng. Master's Thesis. University of Wyoming.

Loose, S. S. 1993. Woodpecker use in the forests of southeast Wyoming. 97pp. Master Thesis. University of Wyoming. Laramie, Wyoming.

Martin, S.K.; Barrett, R.H. 1983. The importance of snags to pine marten habitat in northern Sierra Nevada. Pages 114-116 in J.W. Davis, G.A. Goodwin, and R.A. Ockenfeis, tech. coord. Snag habitat management: proceedings of the symposium. June 7-9, 1983, Northern Arizona University, Flagstaff. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. Gen. Tech. Rept. RM-99.

Mastel, J. 1994. Biological Evaluation for Cedar Timber Sale. Brush Creek-Hayden Ranger District. Medicine Bow National Forest. Laramie, WY.

McKee, D. 1994. Personal Communication. Archaeologist - Brush Creek RD.

Manley, P.N,; Block, W.M.; Thompson, F.R.; Butcher, G.S.; Paige, C; Suring, L.H.; Winn, D.S.; Routh, D.; Ralph, C.J.; Morris, E.; Flather, C.H.; Byford, K. 1993. Guidelines for monitoring populations of neotropical migratory birds on National

Forest System Lands. Monitoring Task Group Report. U.S Department of Agriculture, Forest Service, Washington, D.C.

Mauer, B.A.; Heywood, S.G. 1992. Geographic range fragmentation and abundance in neotropical migratory birds. Conservation Biology 7: 501-509.

Mills, S.H.; Neighbors, M. 1995. Intensive data gathering project (Fine Filter Analysis) for occurrences of rare, threatened, endangered and sensitive species in Sections M331H and M331I, North Central Highlands and Northern Parks and Ranges in Wyoming. Wyoming Natural Diversity Database of THE Nature Conservancy Laramie, WY

Mitchum, D. Fish Pathologist, Wyoming Game and Fish Department. Pers. Comm.

Nesler, T.P. 1994. Western Boreal Toad (*Bufo boreas boreas*) Recovery Plan. State of Colorado, Department of Natural Resources.

Oakleaf, B.; Luce, B; Ritter, S.; Cerovski, A. 1992. Wyoming Bird and Mammal Atlas. Wyoming Game and Fish Department Game Division. Biological Sciences. Lander, Wyoming.

Oberholtzer, M. 1990. Current Status of Colorado River cutthroat trout in the Little Snake River Enclave. Wyoming Game and Fish Department Report 5090-28-8501. Cheyenne.

Oedekovan, O.O. 1985. Columbian shart-tailed grouse population distribution and habitat use in south central Wyoming. Master's Thesis. University of Wyoming, Laramie, WY

Office of Migratory Bird Management. 1982. Nongame migratory bird species with unstable or decreasing populations trends in the United States. Unpublished Administrative Report. U.S. Fish and Wildlife Service Washington, D.C.

Orde, C. 1982. Wood frog survey findings. Specialist Report. Brush Creek District. Medicine Bow National Forest.

Orde, C. and P. Bartlet. 1990. Summary report on the monitoring of effects of logging on the wood frog and its riparian habitat on the Medicine Bow National Forest. Unpublished Specialist Report. Medicine Bow National Forest Laramie, WY.

Partners in Flight - List of migrants Newsletter Winter, 1992 Vol.2 (1)

Quinlan, R.E. 1980. A study on the biology of Colorado River cutthroat trout (*Salmo clarki pleuriticus*) population in the North Fork of the Little Snake River drainage in Wyoming. Master's Thesis. University of Wyoming.

Raley, C.M. 1986. Availability and use of invertebrate food resources by high elevation riparian birds in Southeastern Wyoming. Graduate Thesis, University of Wyoming, Laramie, Wyoming.

Raphael, M. 1987, Preliminary suggestions for monitoring marten on the Medicine Bow National Forest. Report prepared for the Medicine Bow National Forest by the RMFRES, Laramie, WY.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting Accipiter hawks. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins CO. Gen. Tech. Rept. RM-102. 7 pp.

Reynolds, R. T. 1989. Accipiters. In: Proceedings of the western raptor management symposium and workshop; 1987 October 26-28, Boise, Idaho. Washington: National Wildlife Federation, Scientific and Technical Series No. 12:92-101.

Reynolds, R. T.; Linkhart, B.D. 1987. The nesting biology of flammulated owls in Colorado. Pages 239-248 in Nero, R.W.; Clark, R. J.; Knapton, R.J.; Hamre, R.H. eds. Biology and conservation of northern forest owls: symposium proceedings. February 3-7, 1987, Winnipeg, Manitoba, Canada. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins CO. Gen. Tech. Rept. RM-142. 309 pp.

Reynolds, R. T.; Ryder, R.A; Linkhart, B.D. 1989. Small forest owls. Pages 134-143 in Proceedings of the Western raptor management symposium and workshop. National Wildlife Federation, Washington, D. C. Scientific and Technical Series No. 12. 317 pp.

Reynolds, R. T.; Graham,R.T.; Reiser, M.H.; Bassett, R.L.; Kennedy,P.J.; Boyce, D.A.Jr.; Goodwind, G; Smith, R; Fisher, E.L. 1991. Management recommendations for the northern goshawk in the southwestern United States. Northern Goshawk Scientific Committee. USDA Forest Service. Southwestern Region. Albuquerque, New Mexico.

Reynolds, R. T. et al. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins CO. Gen. Tech. Rept. RM-217. 90 pp.

Robertson, D. 1991. Conservation of neotropical birds. U.S. Department of Agriculture, Forest Service. The Friday Newsletter. 20: 1-2.

Robinson, L. 1995. Personal communication. Former Game Warden, WY Game and Fish.

Robbins, C.S. 1979. Effect of forest fragmentation on bird populations. IN: Management of Northcentral and Northeastern Forests for Nongame Birds, 198-212. Proceedings of the workshop, Minneapolis, MN, Jan. 23-25, 1979. U.S. Department of Agriculture, Gen Tech Rep NC-51, North Central Experiment Station.

Rolstad, J. 1991. Consequences of forest fragmentation for the dynamics of bird populations: conceptual issues and the evidence. Biological Journal of the Linnean Society 42: 149-163.

Romme, W. H; Jamieson, D.W; Redders, J.S; Bigsby, G; Lindsey, J.P; Kendall, D; Cowen, R; Kreykes, T; Spencer, A.W; Ortega, J. C. 1992. Old-Growth Forests of the San Juan National Forest in Southwestern Colorado. In: Old-Growth Forests in the Southwest and Rocky Mountain Regions - Proceedings of a Workshop. March 9-13, Portal, Arizona. U.S. Department of Agriculture, Forest Service, Gen Tech Rep RM-213, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colo., 154-165.

Roth, D. - Region 2 Neotropical Migratory Bird Coordinator. List of R-2 Neotropical migrant rankings for abundance of species and threats on breeding grounds for all R-2 National Forests in Wyoming

Roth, D. 1994. Neotropical migratory bird monitoring plan. U.S. Department of Agriculture, Forest Service, Region 2. Draft Report - Monitoring Plan.

Ruggiero, L.F.; Aubry,K.B.; Buskirk, S.W.; Lyon, L.J; Zielinski, W.J. 1994. The scientific basis for conserving forest carnivores: american marten, fisher, lynx and wolverine. USDA Forest Service. General Technical Report RM-254. Fort Collins, CO.

Ryder, R.A., D.A. Palmer, and J.J.Rawinski. 1987. Distribution and status of the boreal owl in Colorado. Pages 169-174 in Nero, R.W.; Clarke, R.J.; Knapton, R.J.; Hamre, R.H. eds. Biology and conservation of northern forest owls: symposium proceedings. Feb. 3-7, 1987, Winnipeg, Manitoba, Canada. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. Gen. Tech. Report RM-142. 309pp.

Samson, F.B. 1980. Island biogeography and the conservation of nongame birds. IN: Transactions of the North American Wildlife and Natural Resources Conference, 45: 245-251.

Schmal, R.N. 1986. Deadman Creek diversion failure assessment of changes in physical habitat and aquatic macroinvertebrates with recommendations for mitigation. Specialist Report Medicine Bow National Forest.

Schmal, R.N.; Young, M.K.; Leonard, V.J. 1995. Conservation status of the Colorado River cutthroat trout. Abstract: Cutthroat session of the Western Division of the American Fisheries Society.

Schulz, T.T; Leininger, W.C. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. Great Basin Naturalist. **51**: 286-292.

Scott, V.E.; Evans, K.E.; Patton, D.R.; Stone, C.P. 1977. Cavity-nesting birds of North American Forests. Agriculture Handbook 511 USDA Forest Service Washington, D.C.

Scott, V.E.; Svoboda, P.L. 1980. Cavity-nesting birds and forest management. IN: Workshop for Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Feb. 11-14, 1980. U.S. Department of Agriculture, Forest Service, Gen Tech Rep INT-86, Rocky Mountain Forest and Range Experimental Station, Ogden, UT.

Sisson, J; Nolde, M.J. 1978. Goshawk - Ecoregion M3113. U. S. Department of Agriculture, Forest Service, Ecological Services, Fort Collins, Colorado.

Snigg, M. A. 1989. Snowy Range lakes survey. Wyoming Game and Fish Department, Fish Division, Administrative Report. Project No. 5089-01-8701. 78 pp.

Smith, K.G. 1980. Non-game birds of the Rocky Mountain spruce-fir forests and their management. IN: Workshop for Management of Western Forests and Grasslands for non-game Birds. USDA Forest Service General Technical Report INT-86. Odgen, UT.

Snow, C. 1972. Habitat management series for endangered species: American peregrine falcon and arctic peregrine falcon. U.S. Department of the Interior. Report No. 1. 35pp. Bureau of Land Management. Denver, Colorado.

Spahr, R., L. Armstrong, D. Atwood, and M. Rath. 1991. Threatened, endangered, and sensitive species of the Intermountain Region. USDA Forest Service, Intermountain Region, Ogden UT.

Shiozawa, D.K.; Evans, R.P.; Williams, R.N. 1994. Relationships between cutthroat trout populations from ten Utah streams in the Colroado River and Bonneville drainages. Utah Division of Wildlife Resources, Ogedn, UT. Final Report. Contract 92-2377.

Speas, C.M.; Fowden, M; Gorges, M.; Rinkes, T; Eaglin, G; Wengert, B. 1994. Conservation plan for Colorado River cutthroat trout (*Onchrhynchus clarki pleuriticus*) for the Little Snake River drainage in southeastern Wyoming. USDA Forest Service, ISDI Bureau of Land Management, Wyoming Game and Fish Department.

Squires, J. Research Wildlife Biologist. 1995. Rocky Mountain Forest and Range Experiment Station. Laramie, Wyoming. Personal communication about his goshawk research.

Squires, J.R.; Ruggiero. 1995. Winter movements of adult northern goshawks that nested in southcentral Wyoming. Journal of Raptor Management 29(1):5-9.

Squires, J.R.; Ruggiero, L.F. 1996. Nest-site selection of northern goshawks in south-central Wyoming. Journal of Wildlife Management (in press)

Stansfield, L. Duerr, D.J.; Kessler, J. 1992. From new perspectives to ecosystem management on the Medicine Bow National Forest: An Analysis of Problems and Opportunities. Submitted to the MBNF. Laramie, WY.

Taylor, D.L., Barmore W.J., Jr. 1980. Post-fire succession of avifauna in coniferous forests of Yellowstone and Grand Teton National Parks, Wyoming. Pages 130-145 in R.M. DeGraff, tech. coord. Management of western forests and grasslands for nongame birds: workshop proceedings. Feb. 11-14, 1980, Salt Lake City, UT. USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden Utah. Gen. Tech. Rept. INT-86. 535 pp.

Temple, S.A.; Cary, J.R. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscape. Conservation Biology 2: 340-347.

Thomas, J.W.; Crouch, G.L.; Bumstead, R.S.; Bryant, L.D. 1975. Silvicultural options and habitat values in coniferous forests. Gen Tech Rep WO-1. U.S. Department of Agriculture, Forest Service.

Troendle, C.A.; King, R.M. 1987. The effect of partial cutting and clearcutting on streamflow at Deadhorse Creek, Colorado. J. Hydrology. 90: 145-157.

Tuttle, M.D. 1984. The bats of Colorado. Colorado Division of Wildlife. Denver, CO.

Udvardy, M. D. F. 1977. The Audubon Society Field Guide to North American Birds. Western Region. Alfred A. Knopf, Inc., New York,NY.

USDA Forest Service. 1981. Wildlife and fish habitat relationships: volume I, narratives. Rocky Mountain Region. Denver, Colorado.

USDA Forest Service. 1994. Draft - Threatened, endangered, sensitive or rare species conservation strategy.

von Ahlefeldt, J. 1993. Medicine Bow National Forest Sensitive Plant Species. Medicine Bow National Forest. Laramie, WY.

Ward, L.Z., Ward, D.K, Tibbits, T.J. 1992. Canopy density analysis at goshawk nesting territories on the North Kaibab Ranger District, Kaibab National Forest. Nongame and Endangered Wildlife Program. Arizona Game and Fish Department, Phoenix, AZ.

Wesche, T.A.; Reiser, D.W.; Wichers, W.F.; Wichers, D.L. 1977. Fishery resources and instream flow recommendations for streams to be impacted by Cheyenne's proposed phase II development report submitted to Wyoming Game and Fish Department.

Wilcox, M. 1989. Green Timber Creek timber sale Specialist Report. Medicine Bow National Forest.

Wyoming Game and Fish. 1992. Annual big game herd unit report, District V. Volume XVII (5). Cheyenne, WY.

Wyoming Game And Fish. 1994. Harvest and population data are from the Wyoming Game and Fish Department, Cheyenne, Wyoming.

Young, M.A. Research Scientist. USDA Forest Service, Rocky Mountain Experimental Station. Pers. comm. 1993.

Young, M.K. 1989. Effect of substrate composition on the survival and emergence of Colorado River cutthroat trout and brown trout. PhD Dissertation. University of Wyoming, Laramie, WY.

Young, M.K. 1995. Colorado River cutthroat trout. IN: Conservation assessment for inland cutthroat trout. USDA Forest Service General Technical Report RM-GTR-256. Fort Collins, CO.

Zimmerman, M.L. 1995. A study of moose herbivory on willow communities in Colorado. Master's Thesis (In progress). Colorado State University, Fort Collins, CO.

MEDICINE BOW NATIONAL FOREST

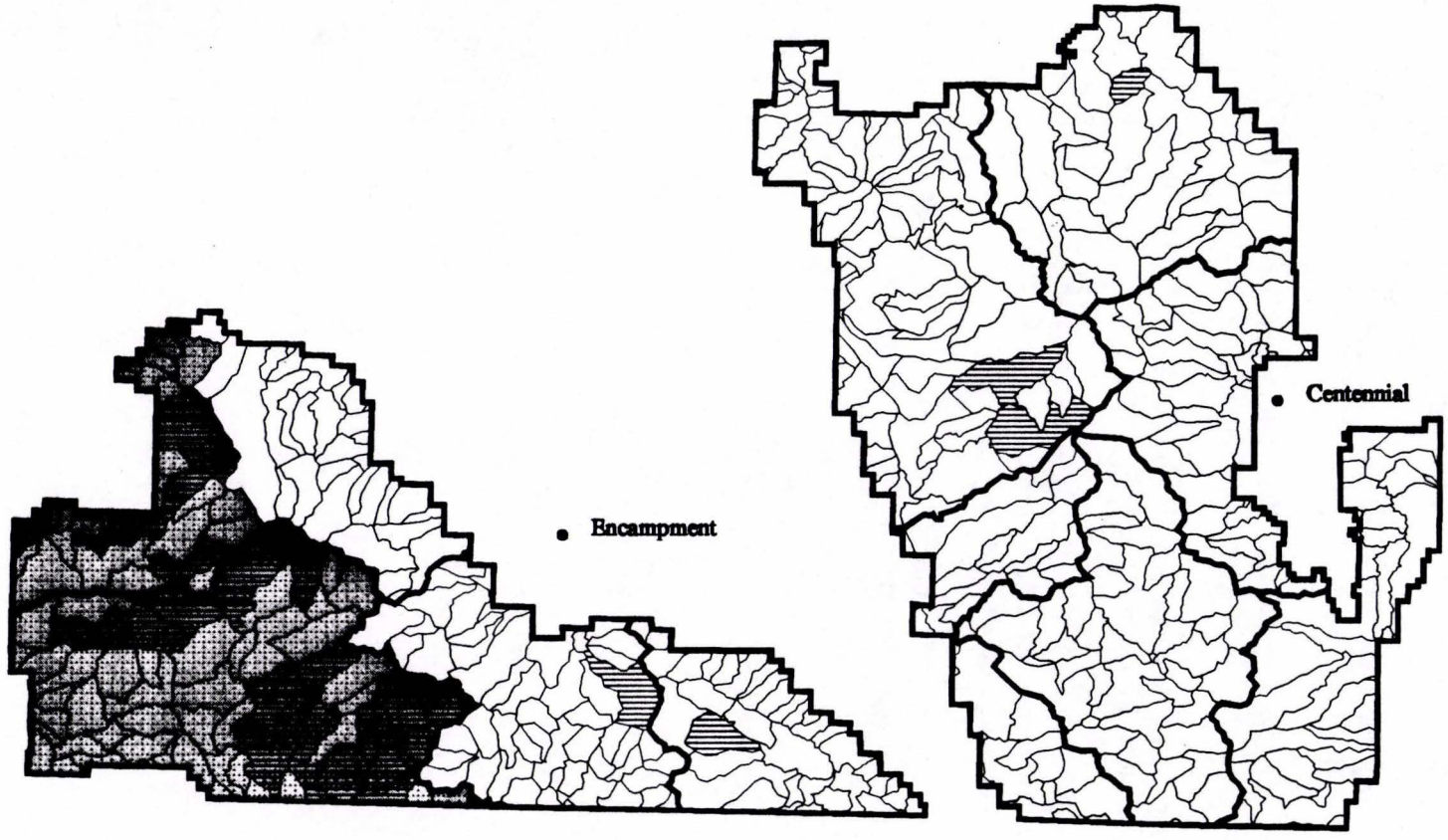
SIERRA MADRES and SNOWY RANGE

Colorado River Cutthroat Trout Distribution Map

FIGURE 8.1

LEGEND

- Current Distribution
- Historical Distribution (From Behnke, 1992)
- 8th Level Waterahed Boundary
- Biodiversity Area Boundary



1 to 600,000

MEDICINE BOW NATIONAL FOREST

SIERRA MADRES and SNOWY RANGE

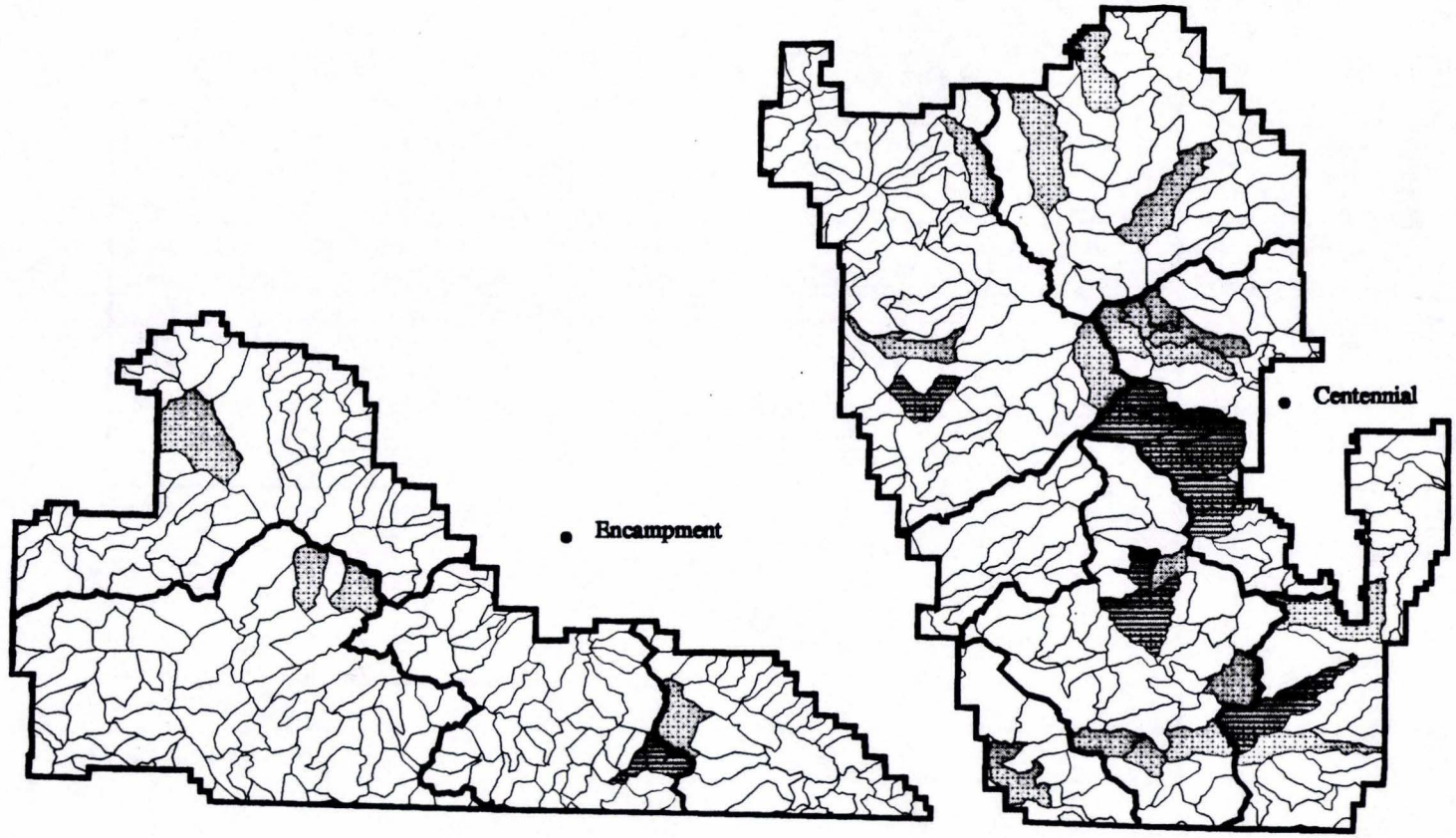
Boreal Toad Distribution Map

FIGURE 8.2a

LEGEND

- Current Distribution (based on known occurance post 1985)
- Historical Distribution (based on known occurance pre 1985)
- 8th Level Watershed Boundary
- Biodiversity Area Boundary

Range of boreal toad as described by Baxter and Stone (1980) is the entire Medicine Bow N.F.

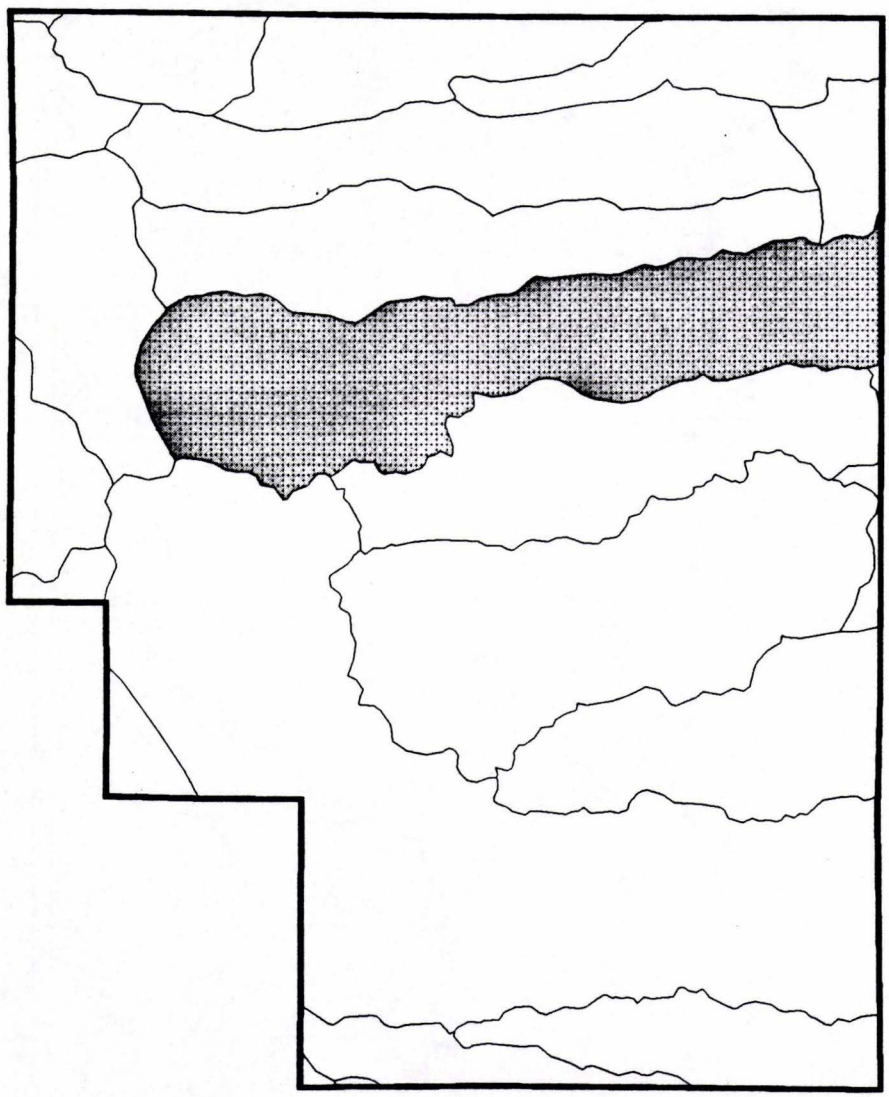


Scale 1 to 600,000

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Boreal Toad Distribution Map

FIGURE 8.2b



Created by CLT for CS, 05.02.95, boreal shermans.aml

LEGEND

- Current Distribution (based on known occurance post 1985)
- Historical Distribution (based on known occurance pre 1985)
- 8th Level Watershed Boundary
- Biodiversity Area Boundary

Range of boreal toad as described by Baxter and Stone (1980) is the entire Medicine Bow N.F.

Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST

SIERRA MADRES and SNOWY RANGE

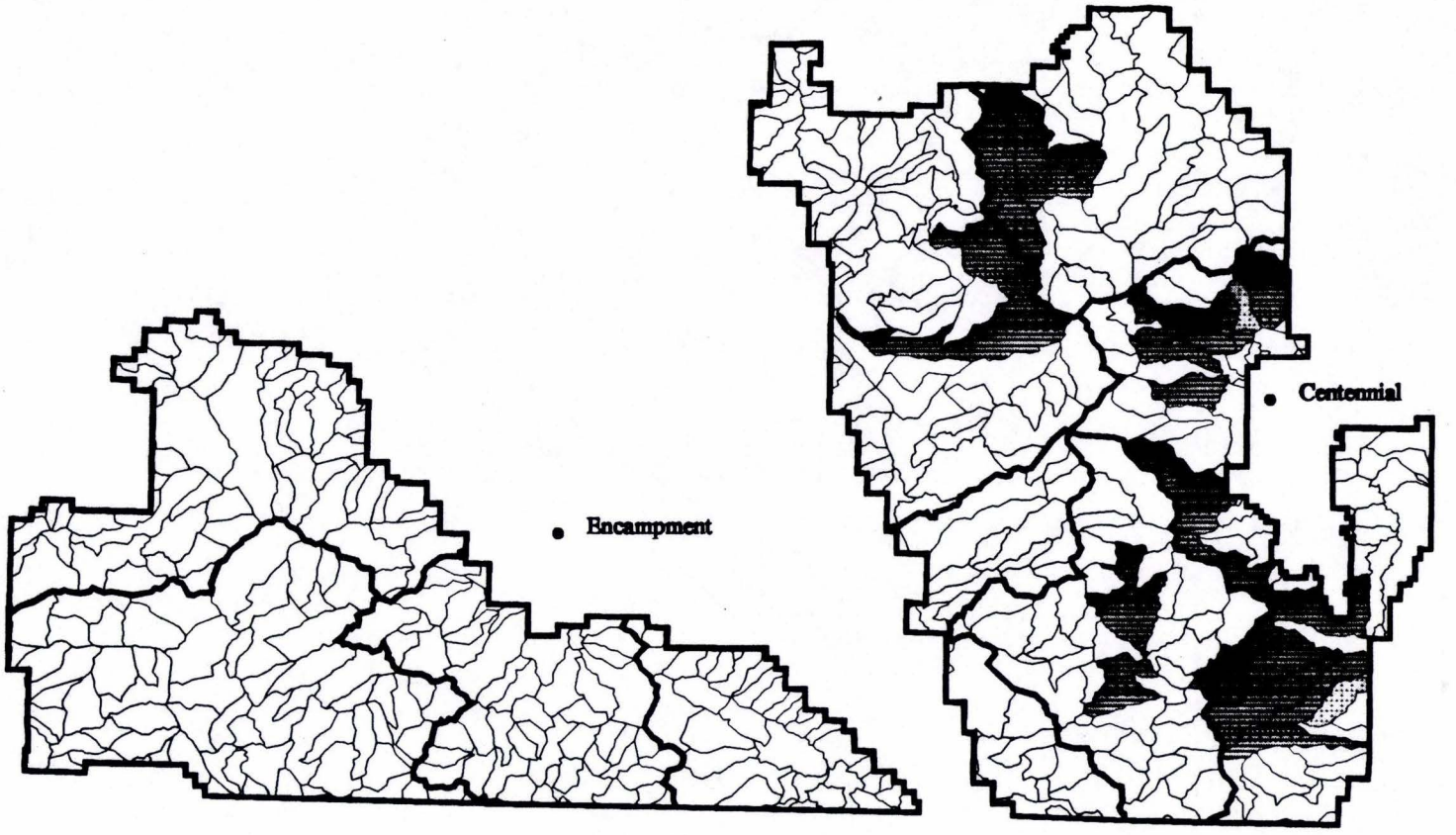
Wood Frog Distribution Map

FIGURE 8.3

LEGEND

- Current Distribution (based on known occurance post 1985)
- Historical Distribution (based on known occurance pre 1985)
- 8th Level Watershed Boundary
- Biodiversity Area Boundary

Range of wood frog as described by Baxter and Stone (1980) is between 7,5000 ft and 10,000 ft elevation.



Scale 1 to 600,000

MEDICINE BOW NATIONAL FOREST

Mule Deer Seasonal Ranges

SIERRA MADRES and SNOWY RANGE

FIGURE 8.4a

LEGEND

SSF
Seasonal Spring / Fall Range

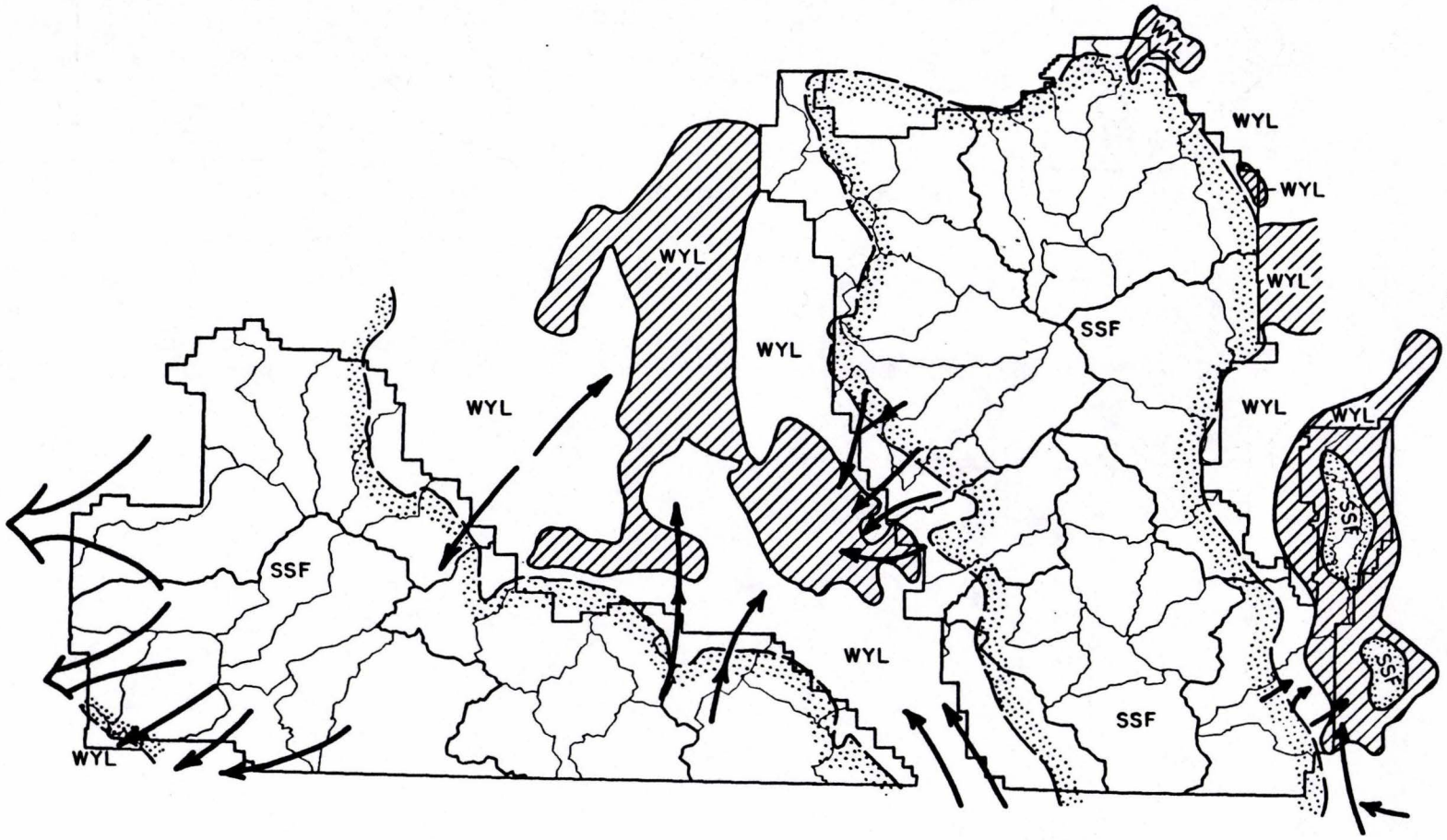
WYL
Winter Yearlong Range

Crucial Range

Migration Pathway

Biodiversity Unit Boundary

Biodiversity Area Boundary



Scale 1 to 600,000

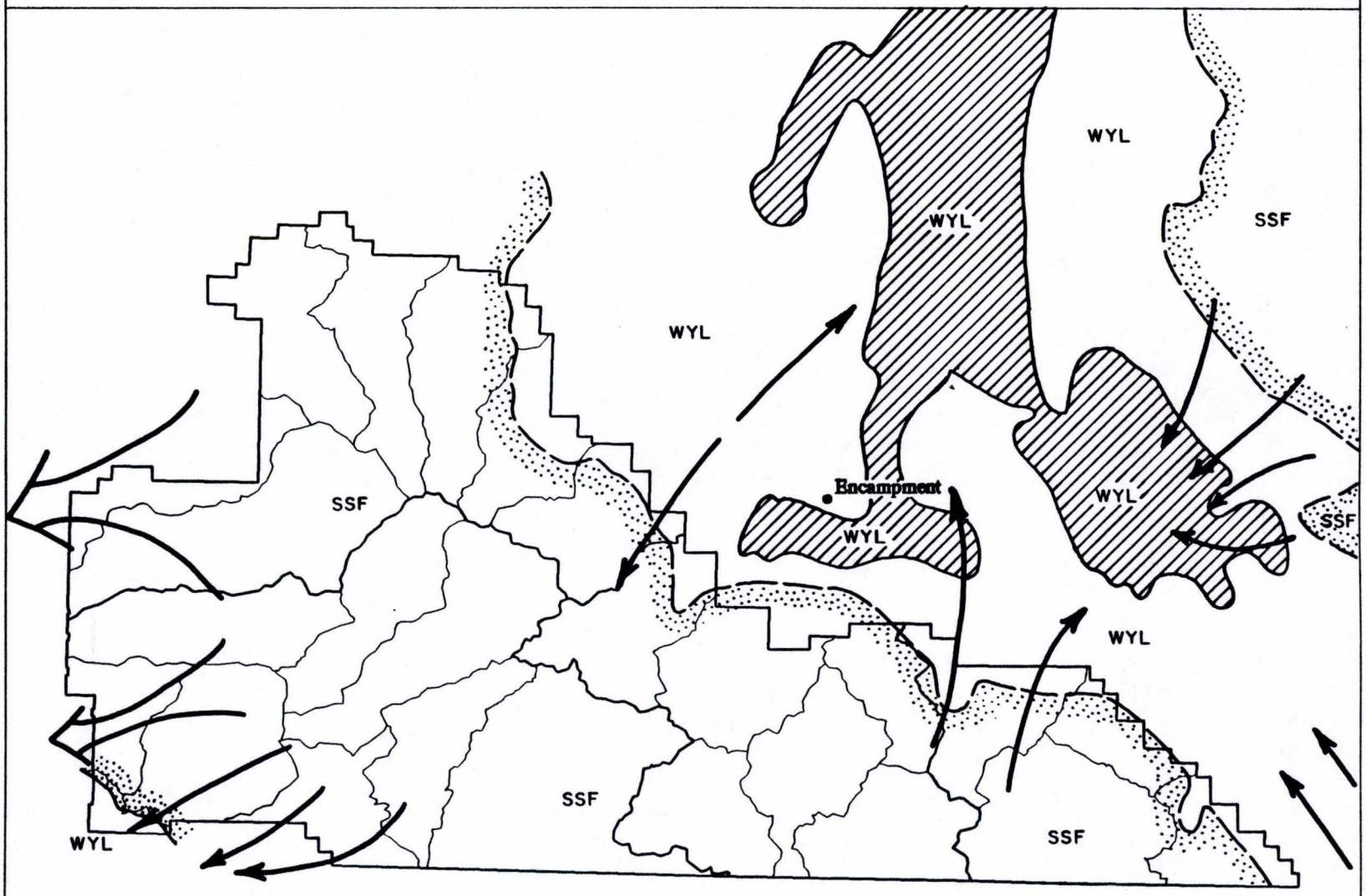
Based on Wyoming Game and Fish Department Seasonal Range Maps - Revised 8/87

MEDICINE BOW NATIONAL FOREST

Mule Deer Seasonal Ranges

SIERRA MADRES

FIGURE 8.4b



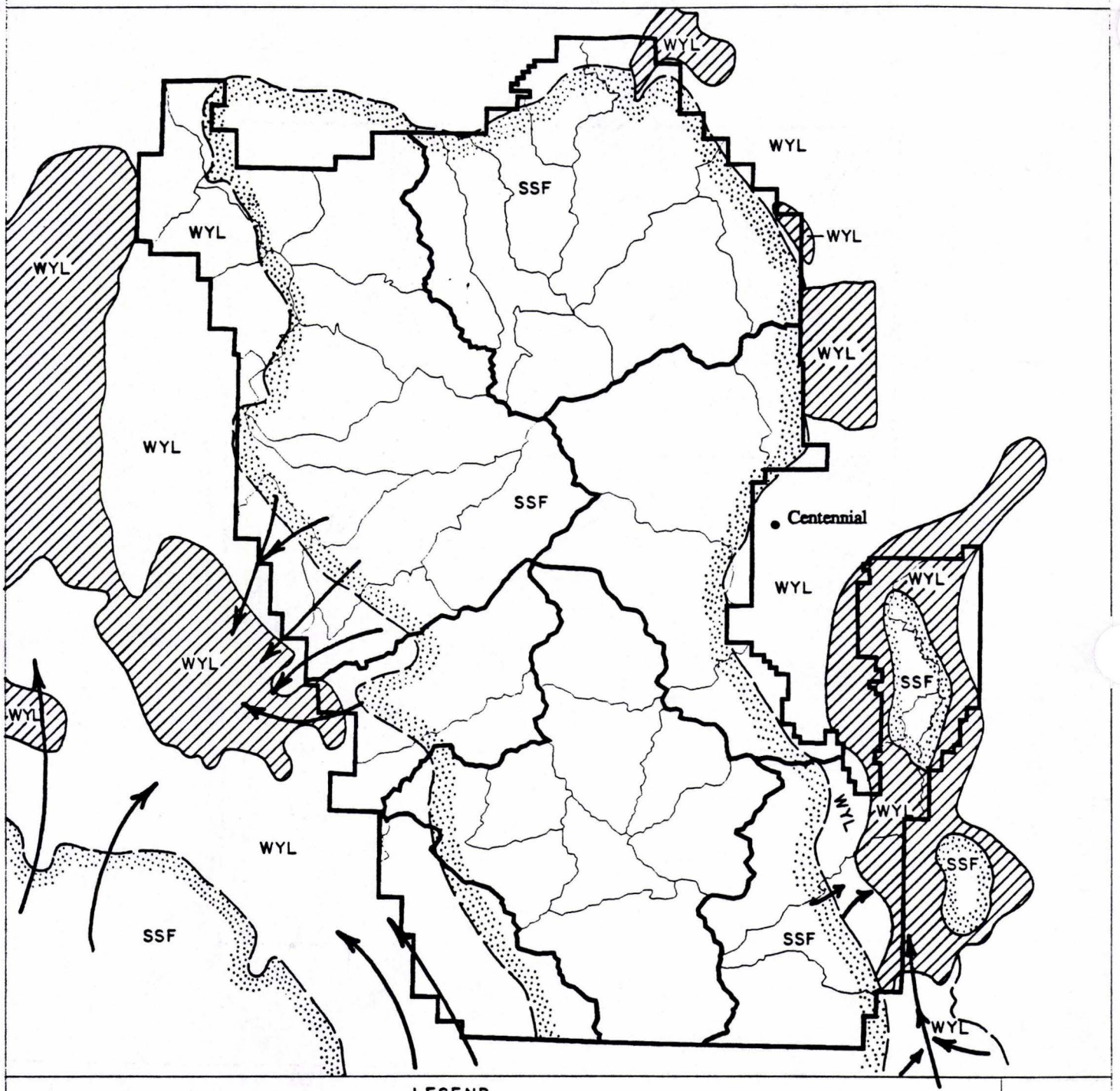
Based on Wyoming Game and Fish Department Seasonal Range Maps — Revised 8/87

MEDICINE BOW NATIONAL FOREST

Mule Deer Seasonal Ranges

SNOWY RANGE

FIGURE 8.4c



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- Crucial Range
- Migration Pathway
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

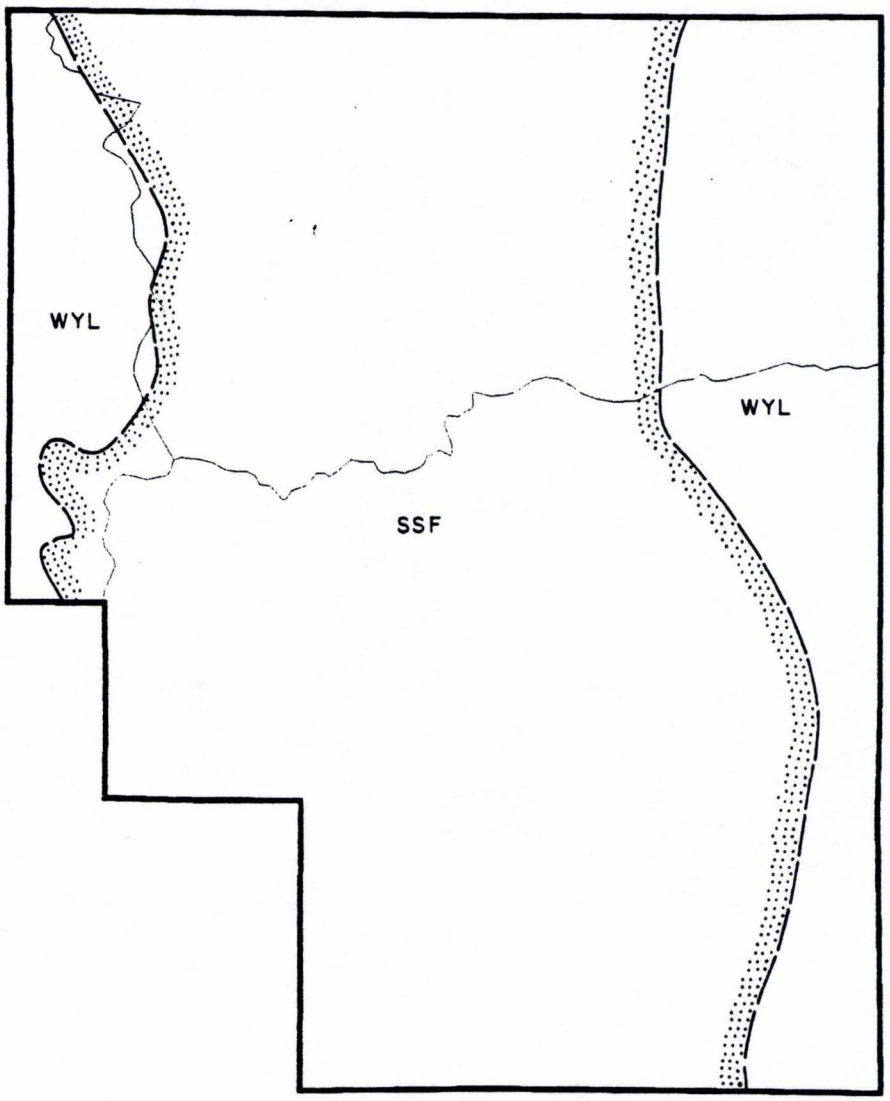
Scale 1 to 375,000

Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Mule Deer Seasonal Ranges

FIGURE 8.4d



LEGEND

SSF — Seasonal Spring/Fall Range

WYL — Winter Yearlong Range

Biodiversity Unit Boundary

Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

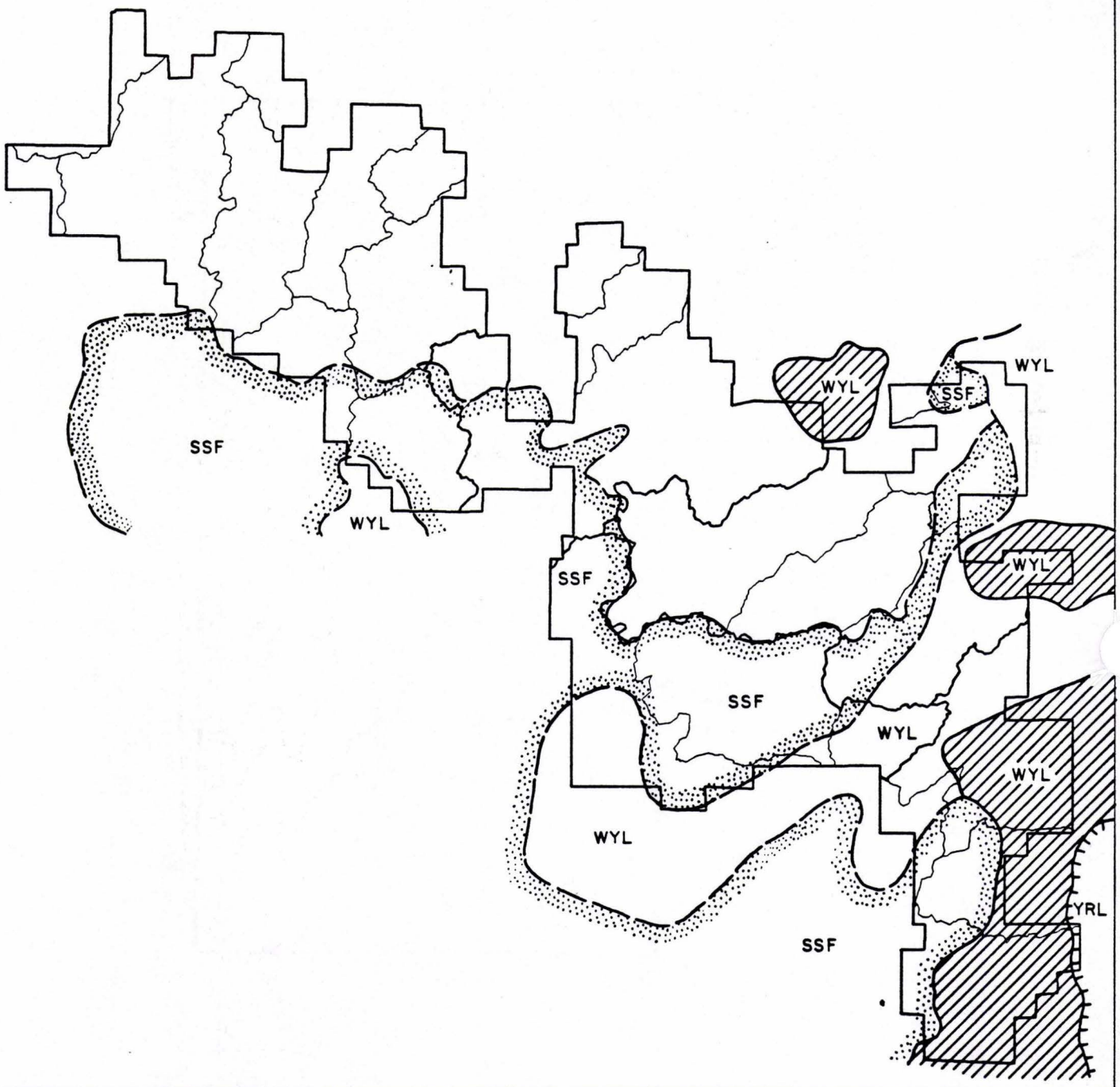
Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST

Mule Deer Seasonal Ranges

LARAMIE RANGE

FIGURE 8.4e



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- YRL — Yearlong Range
- Crucial Range
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

Scale 1 to 425,000

MEDICINE BOW NATIONAL FOREST

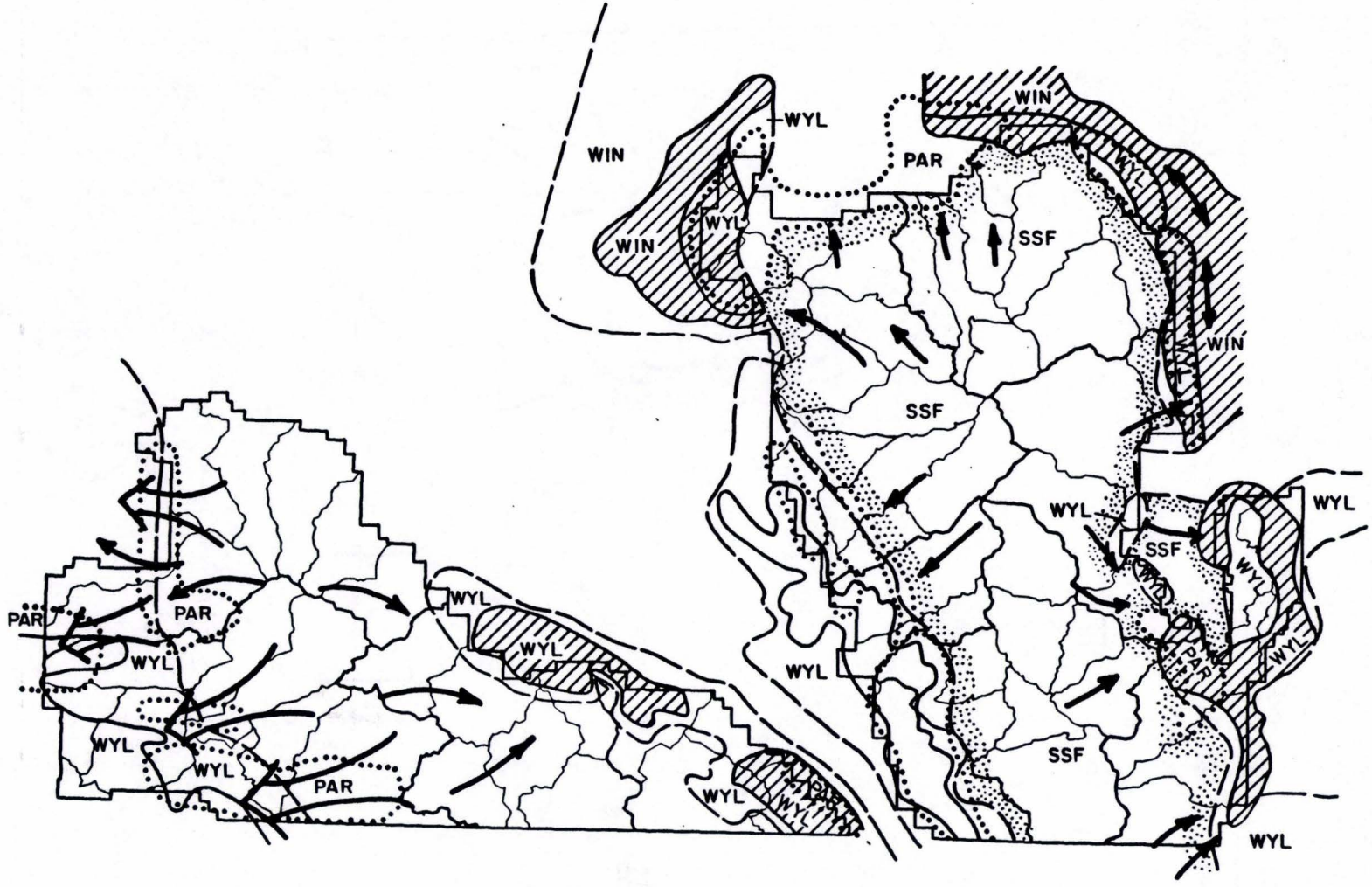
Elk Seasonal Ranges

SIERRA MADRES and SNOWY RANGE

FIGURE 8.5a

LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- WIN — Winter Range
- PAR — Parturition
- Crucial Range
- Migration Pathway
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Based on Wyoming Game and Fish Department Seasonal Range Maps — Revised 8/87

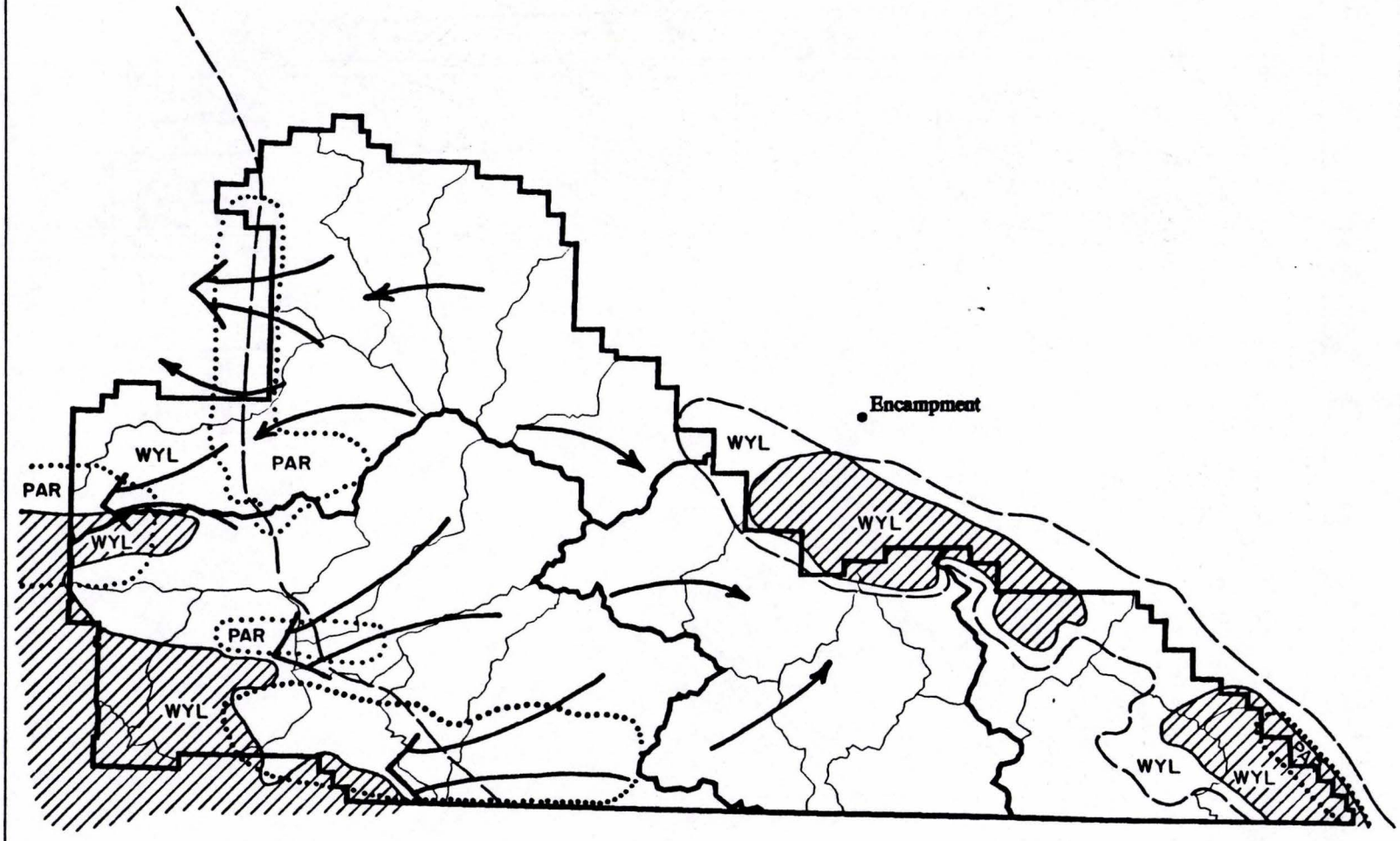
Scale 1 to 600,000

MEDICINE BOW NATIONAL FOREST

Elk Seasonal Ranges

SIERRA MADRES

FIGURE 8.5b



LEGEND

WYL — Winter Yearlong Range

PAR — Parturition

Crucial Range

Migration Pathway

Biodiversity Unit Boundary

Biodiversity Area Boundary

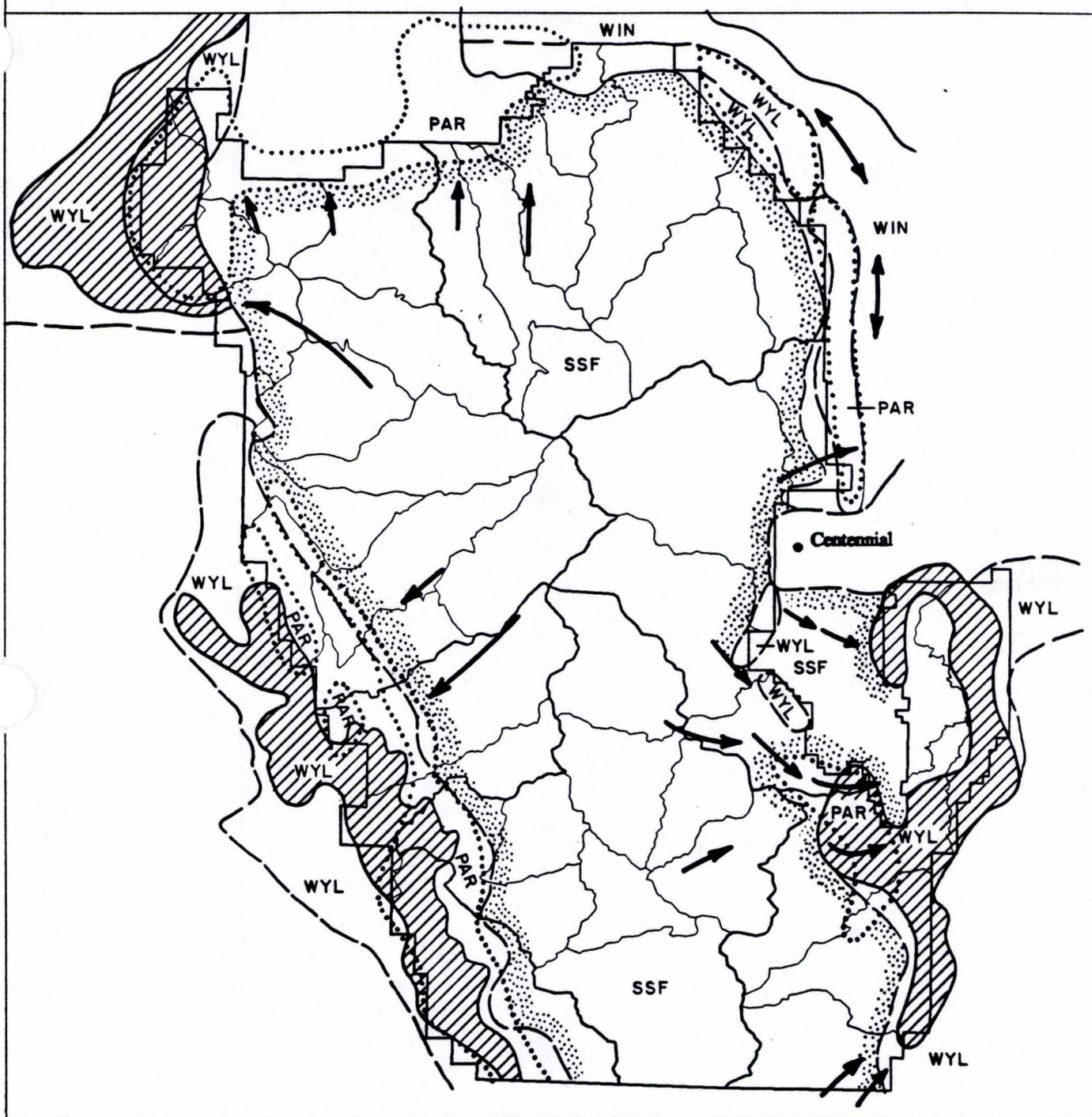
Scale 1 to 375,000

Based on Wyoming Game and Fish Department Seasonal Range Maps — Revised 8/87

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Elk Seasonal Ranges

FIGURE 8.5c



LEGEND

SSF	Seasonal Spring / Fall Range		Crucial Range
WYL	Winter Yearlong	→	Migration Pathway
WIN	Winter Range	—	Biodiversity Unit Boundary
PAR	Parturition	—	Biodiversity Area Boundary

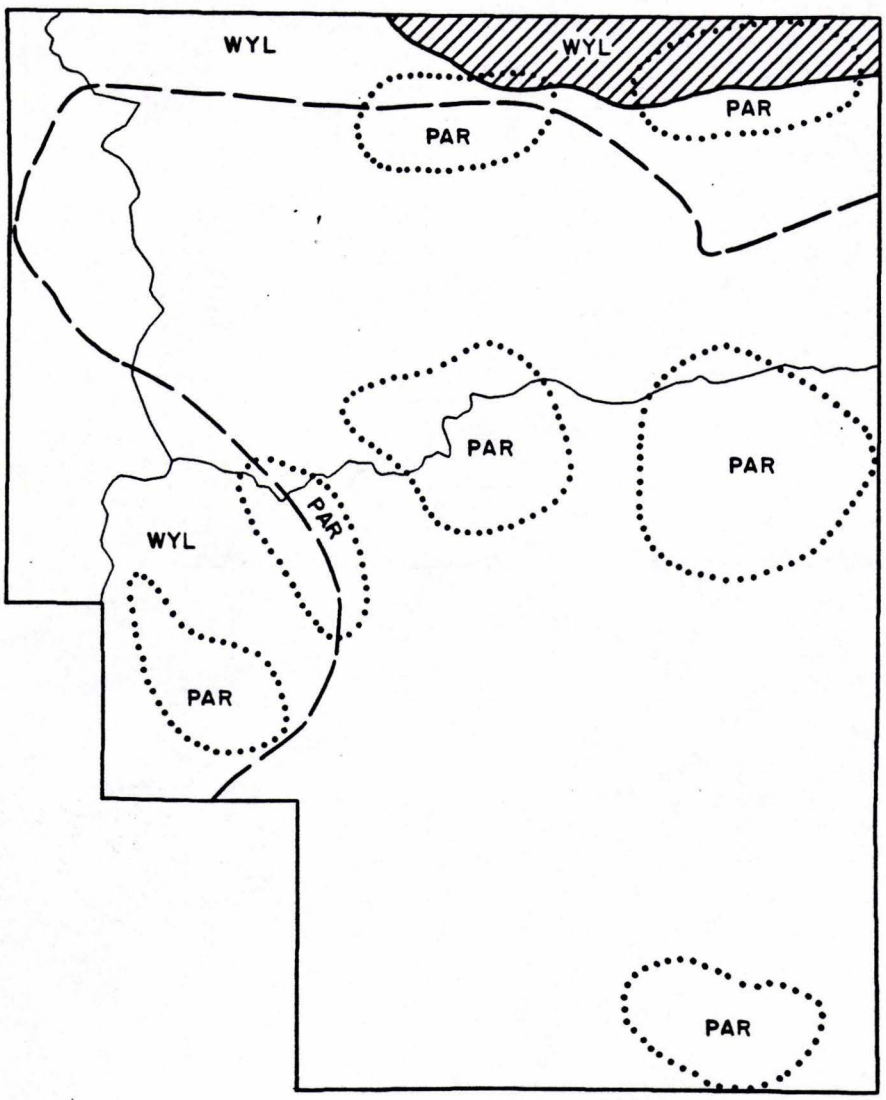
Based on Wyoming Game and Fish Department Seasonal Range Maps - Revised 8/87

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Elk Seasonal Ranges

FIGURE 8.5d



WYL Winter Yearlong Range

PAR Parturition

Crucial Range

Biodiversity Unit Boundary

Based on Wyoming Game and Fish Seasonal Range Maps – Revised 8/87

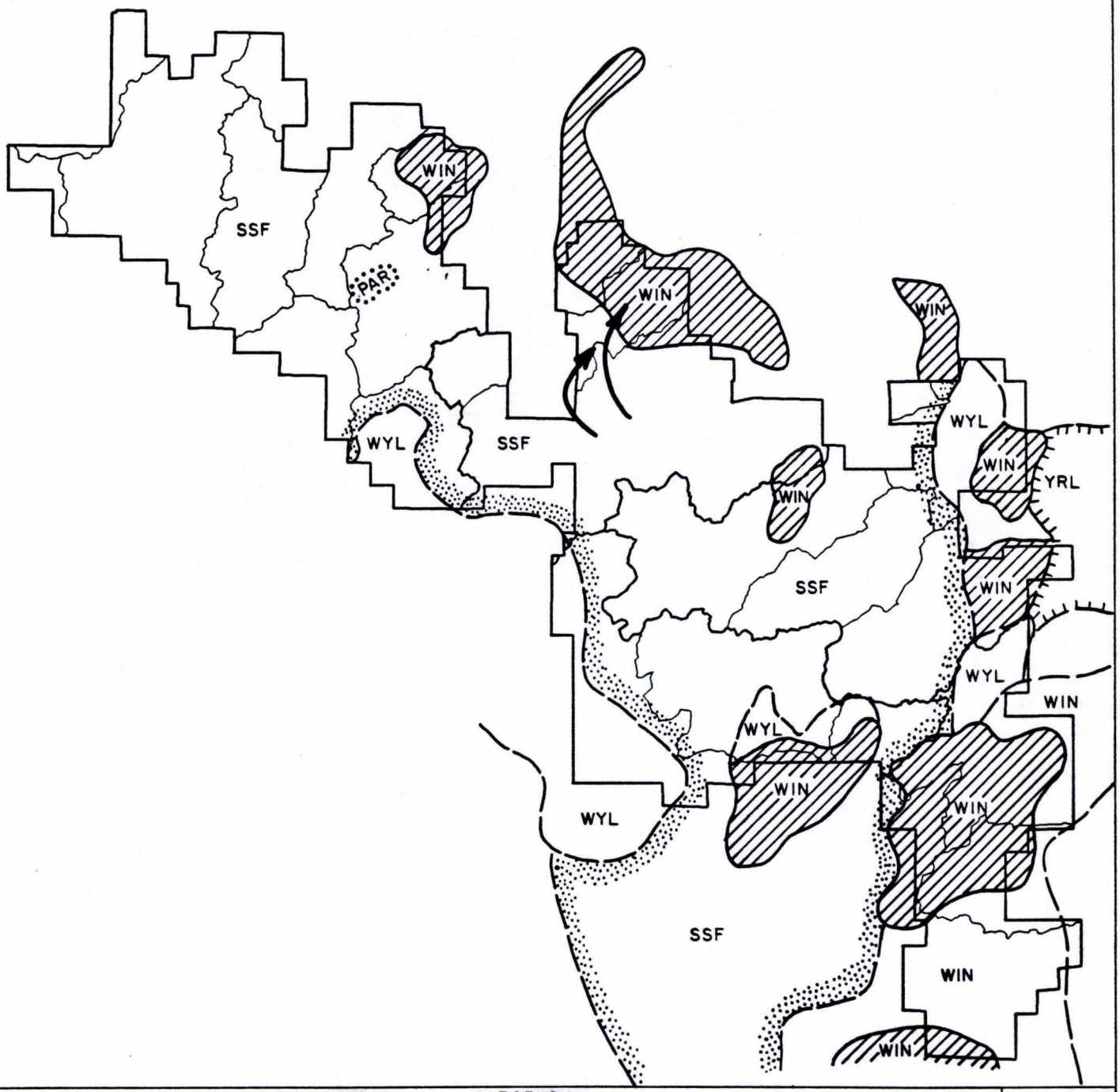
Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST

Elk Seasonal Ranges

LARAMIE RANGE

FIGURE 8.5e



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- WIN — Winter Range
- YRL — Yearlong Range
- PAR — Parturition
- Crucial Range
- Migration Pathway
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Based on Wyoming Game and Fish Seasonal Range Maps - Revised 8/87

MEDICINE BOW NATIONAL FOREST

SIERRA MADRES and SNOWY RANGE

Antelope Seasonal Ranges

FIGURE 8.6a

LEGEND

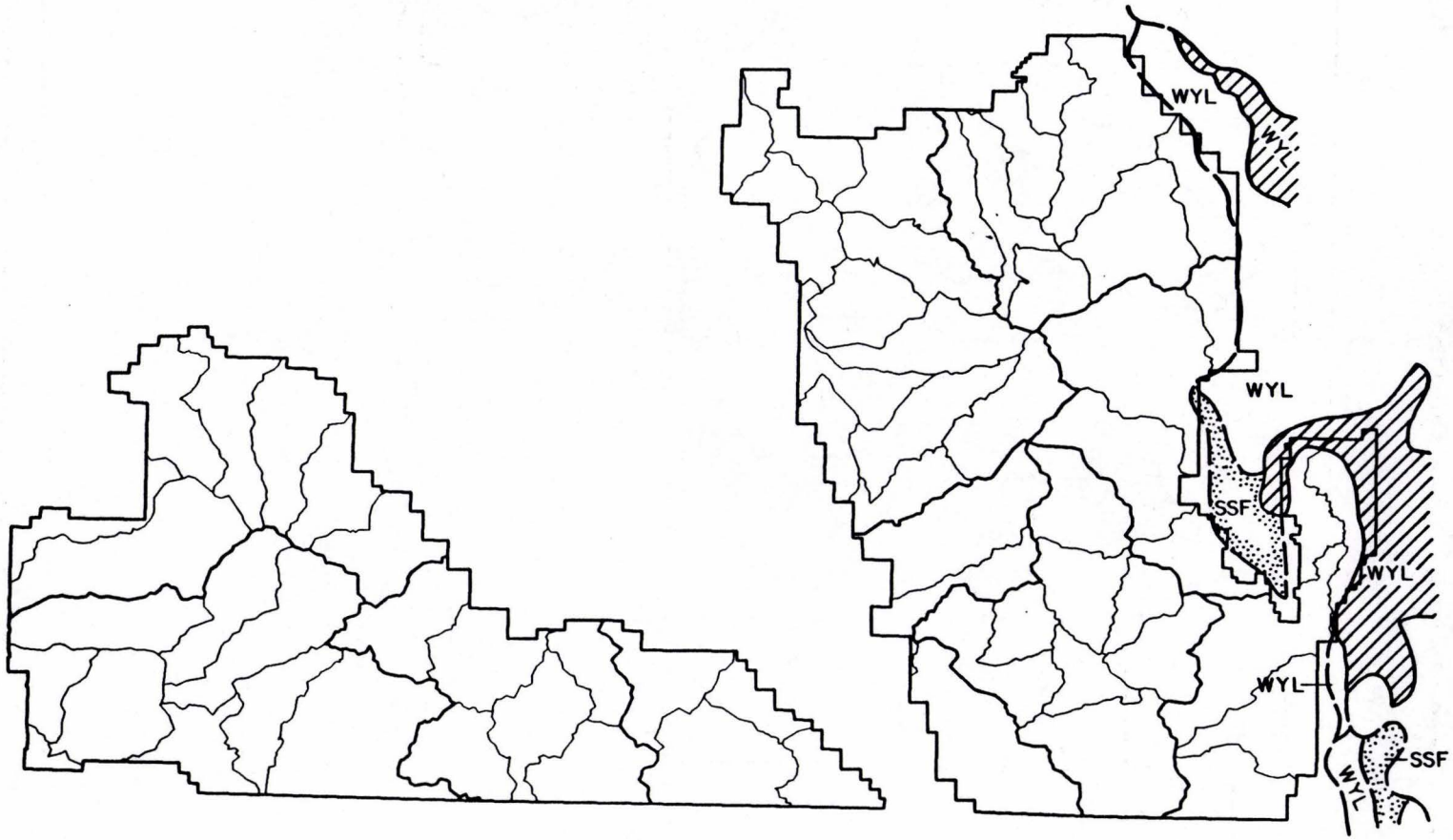
SSF
Seasonal
Spring/Fall Range

WYL
Winter Yearlong Range

Crucial Range

Biodiversity Unit
Boundary

Biodiversity Area
Boundary



Scale 1 to 600,000

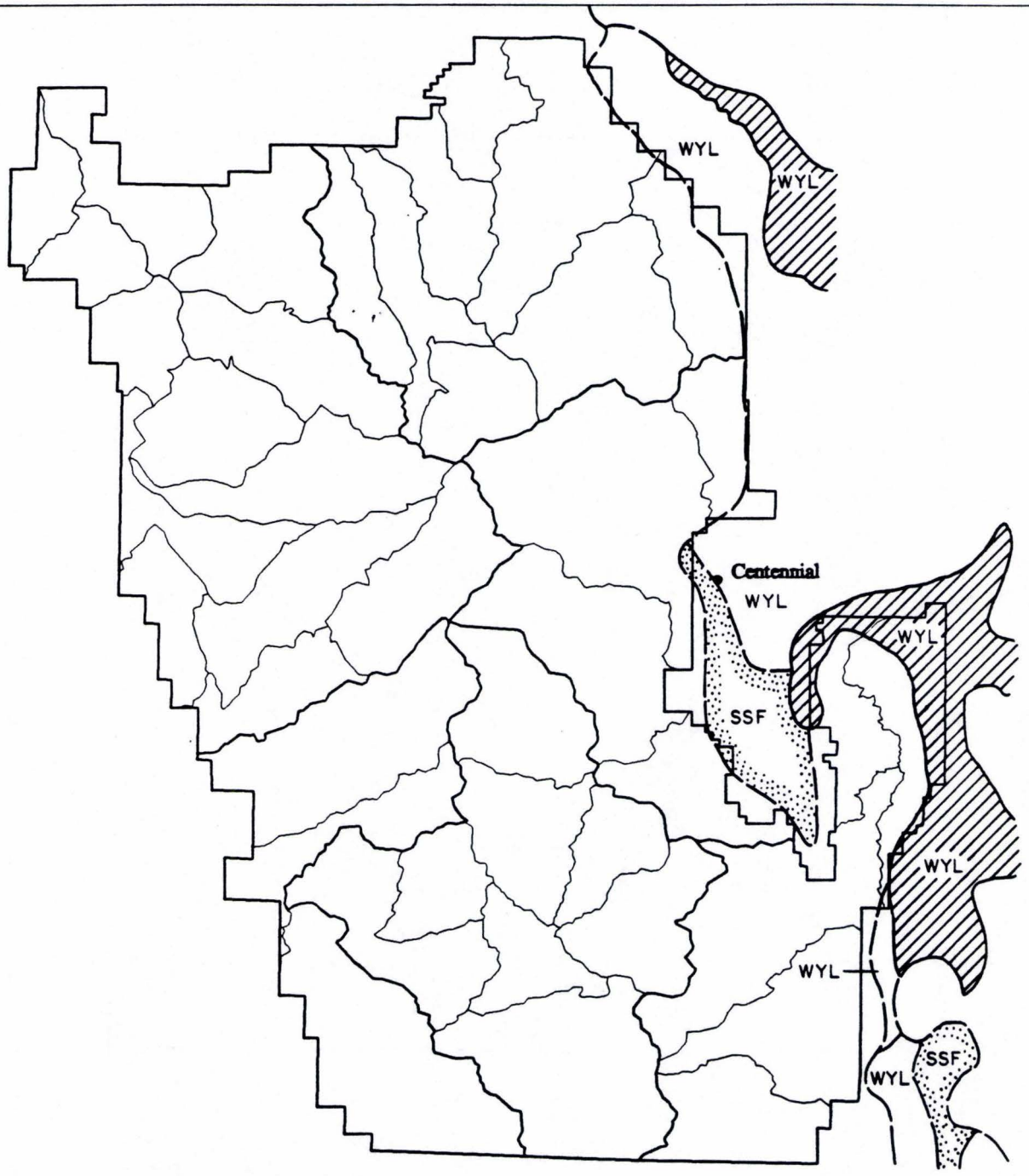
Based on Wyoming Game and Fish Departme asonal Range Maps – Revised 8/87

MEDICINE BOW NATIONAL FOREST

Antelope Seasonal Ranges

SNOWY RANGE

FIGURE 8.6b



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- Crucial Range
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

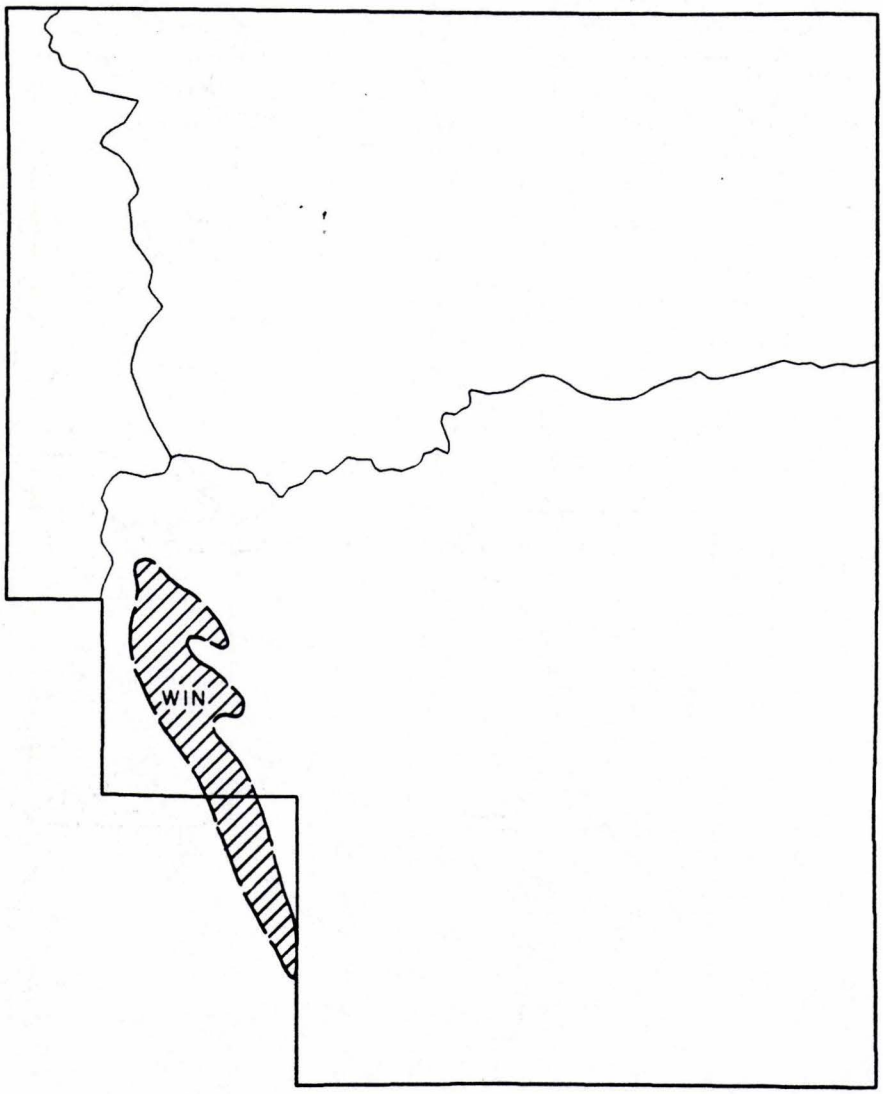
Scale 1 to 375,000

Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Antelope Seasonal Ranges

FIGURE 8.6c



LEGEND

WIN | Winter Range

Crucial Range

Biodiversity Unit Boundary

Scale 1 in 125,000

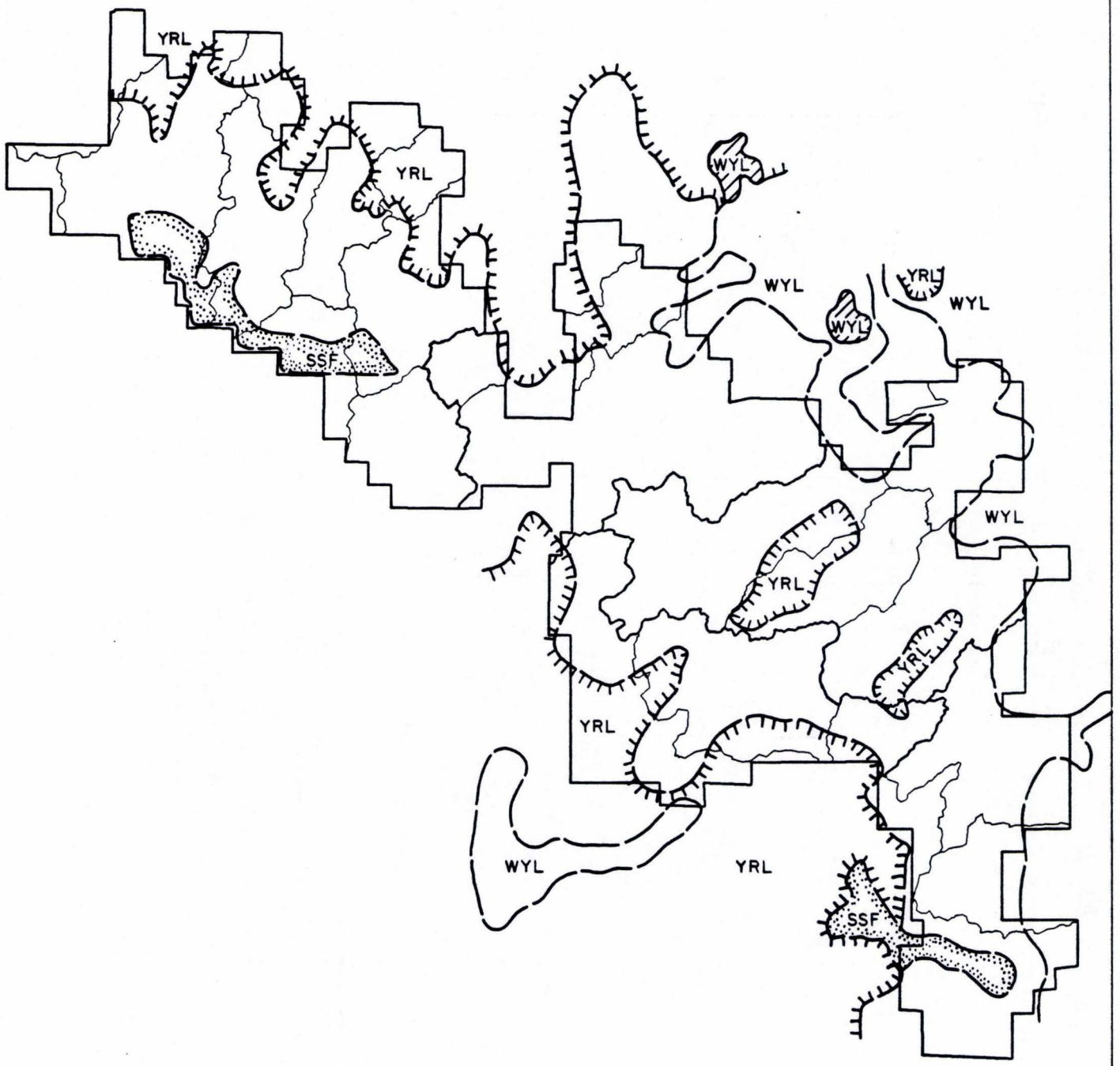
Based on Wyoming Game and Fish Department Seasonal Range Maps - Revised 8/87

MEDICINE BOW NATIONAL FOREST

Antelope Seasonal Ranges

LARAMIE RANGE

FIGURE 8.6d



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong
- YRL — Yearlong Range
- Crucial Range
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

Scale 1 to 425,000

MEDICINE BOW NATIONAL FOREST

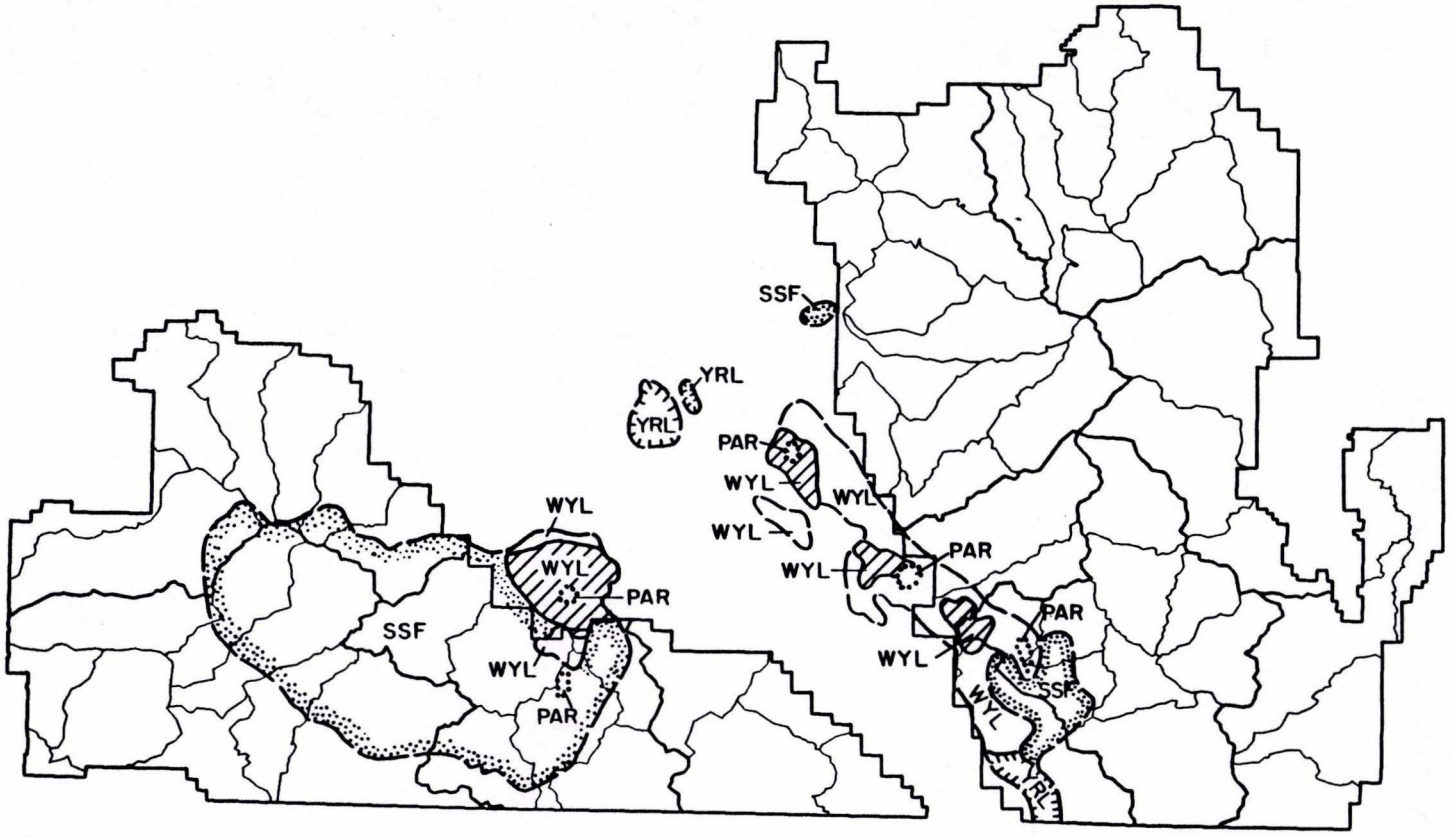
Bighorn Sheep Seasonal Ranges

SIERRA MADRES and SNOWY RANGE

FIGURE 8.7a

LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- YRL — Yearlong Range
- PAR — Parturition
- Crucial Range
- Migration Pathway
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 600,000

Based on Wyoming Game and Fish Depart Seasonal Range Maps - Revised 8/87

MEDICINE BOW NATIONAL FOREST

Bighorn Sheep Seasonal Ranges

SIERRA MADRES

FIGURE 8.7b

LEGEND

SSF
Seasonal Spring/Fall Range

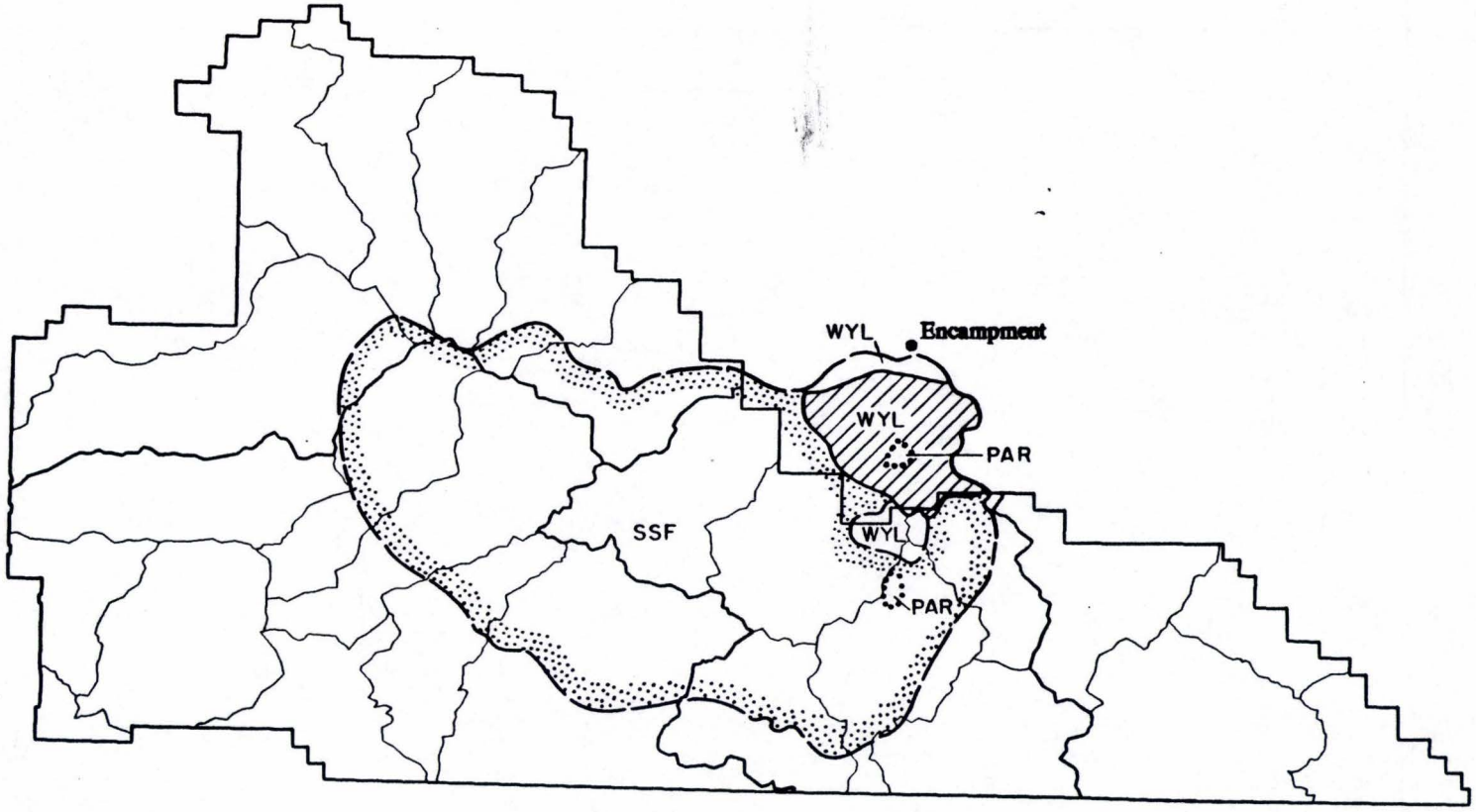
WYL
Winter Yearlong Range

PAR
Parturition

Crucial Range

Biodiversity Unit Boundary

Biodiversity Area Boundary



Scale 1 to 375,000

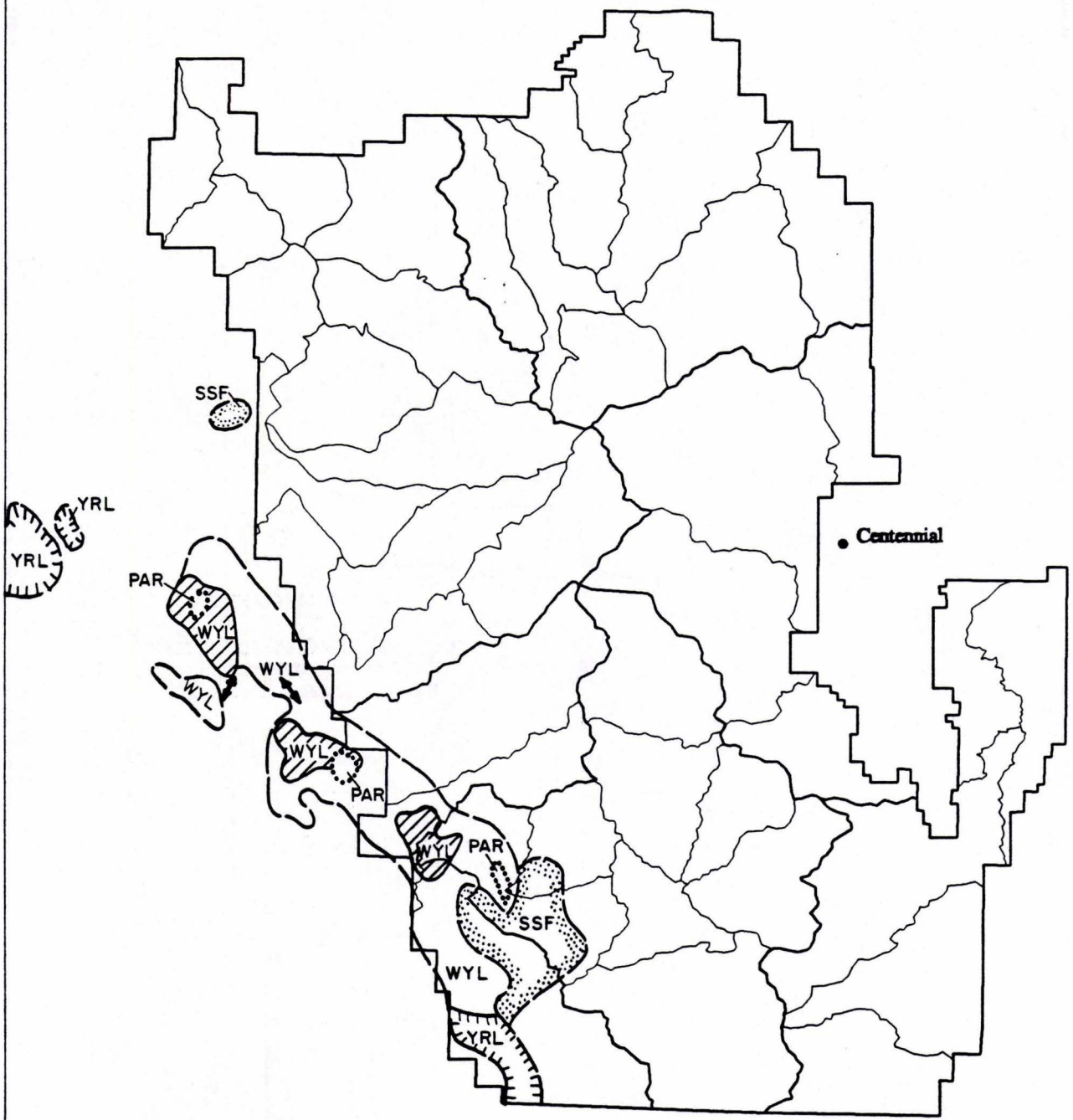
Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

MEDICINE BOW NATIONAL FOREST

Bighorn Sheep Seasonal Ranges

SNOWY RANGE

FIGURE 8.7c



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- YRL — Yearlong Range
- PAR — Parturition
- Crucial Range
- Migration Pathway
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

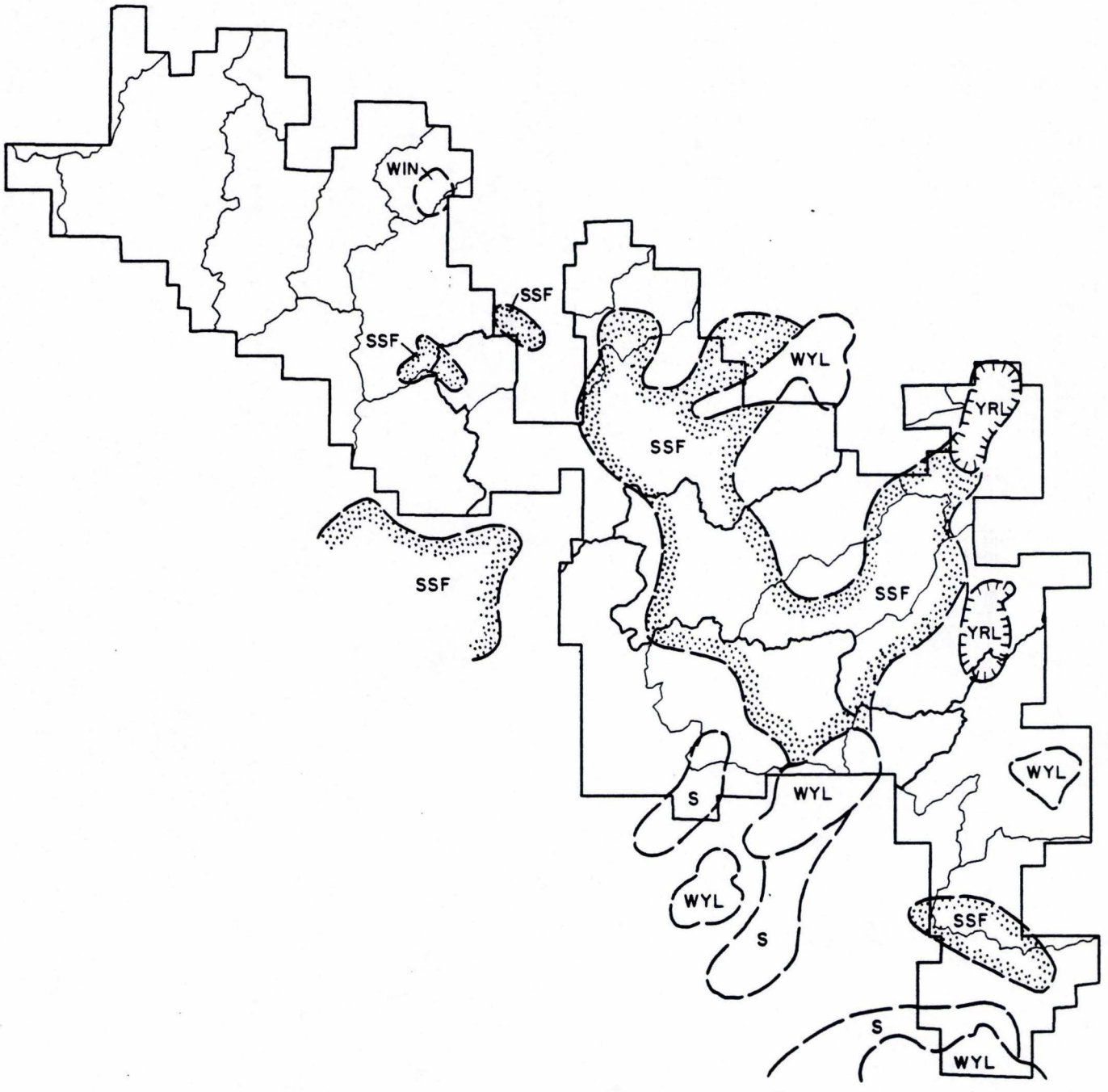
Based on Wyoming Game and Fish Department Seasonal Range Maps – Revised 8/87

MEDICINE BOW NATIONAL FOREST

LARAMIE RANGE

Bighorn Sheep Seasonal Ranges

FIGURE 8.7d



LEGEND

- SSF — Seasonal Spring/Fall Range
- WYL — Winter Yearlong Range
- WIN — Winter Range
- YRL — Yearlong Range
- S — Summer Range
- Crucial Range
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Based on Wyoming Game and Fish Department Seasonal Range Maps - Revised 8/87

Scale 1 to 425,000

CHAPTER 9

WILDERNESS AREAS, ROADLESS AREAS, RESEARCH NATURAL AREAS, AND OLD GROWTH

INTRODUCTION

Locations, acreages, and characteristics of wilderness areas, research natural areas, roadless areas, the Sheep Mountain Federal Game Refuge, and designated old growth are presented in this chapter. Old growth identification and management, use of roadless areas and the land allocation to additional research natural areas are important components of biodiversity issues on the MBNF. A landscape ecology design concept to connect small, isolated designated old growth stands with wilderness; existing, potential and proposed research natural areas; portions of roadless areas; and other sites with old growth values, is synthesized in the Old Growth Patch and Linkage System for the Sierra Madre and Medicine Bow Mountains presented in this report.

Most areas of the Medicine Bow National Forest are open to a full range of multiple uses including timber harvest, grazing, hunting, and recreation. These areas offer a particular suite of biological diversity characteristics.

As a group wilderness areas (WA), roadless areas (RA), designated old growth sites (DOG), research natural areas (RNA), and the Sheep Mountain Federal Wildlife Refuge provide a different suite of biological diversity values from lands open to a full spectrum of multiple uses. They provide an opportunity for landscape-scale management of late seral forest and associated ecosystems. Natural disturbances (with the exception of man-caused fires) are the primary disturbance agents, as contrasted with intermittent man-caused disturbances (such as timber harvest or mining) or chronic disturbance (such as grazing and some types of recreational uses). Fire suppression has affected natural disturbance regimes for all lands.

Different multiple uses apply to WA, RA, RNA and DOG. Timber harvest is not permitted in wilderness, designated old growth or research natural areas. Timber harvest may occur in roadless areas if an EIS is prepared. On the MBNF timber sales were suspended for roadless areas in 1994 pending Forest Plan revision. Grazing is not permitted in research natural areas except under special circumstances. Recreation is permitted in all areas, but may be restricted in RNAs as need to protect RNA values. Roads are not allowed in wilderness areas, roadless areas or RNAs. Although most designated old growth sites are not associated with roads, there are no Forest Plan restrictions on roading for

designated old growth. Sheep Mountain is a Federal Wildlife Refuge. Neither timber harvest nor grazing are allowed, although water from Fence Creek is diverted for irrigation and hunting occurs.

WILDERNESS AREAS

The MBNF has four wilderness areas (Huston Park and Encampment River in the Sierra Madre Mountains, and Savage Run and Platte River in the Medicine Bow Mountains). The Huston Park, Encampment River and Platter River Wilderness areas were formed from roadless areas identified in the RARE II Inventory (1979). Two small additions to the existing Savage Run Wilderness were made from RARE II Inventoried Roadless Areas.

In the Sierra Madre and Medicine Bow Mountains, a total of 78,265 acres of wilderness includes about nine percent of the net National Forest System (NFS) acres in these two mountain ranges. Wilderness comprises about seven percent of the entire Medicine Bow National Forest net acreage when the Sherman Mountains and Laramie Mountains (which have no wilderness areas) are included (Table 9.1).

Table 9.1 Wilderness Area Acreages and Percent of Mountain Range*

SIERRA MADRE MOUNTAINS		
Huston Park	30,648 Acres	9% of Sierra Madre
Encampment River	10,400 Acres	3% of Sierra Madre
	41,048 Acres	12% of Sierra Madre
MEDICINE BOW MOUNTAINS		
Savage Run	15,068 acres	3% of MB Mountain
Platte River	22,179 acres	4% of MB Mountains
	37,247 acres	7% of MB Mountains
SHERMAN MOUNTAINS	none	
LARAMIE MOUNTAINS	none	
SUM OF WILDERNESS	78,295 acres	9% of net SM + MB acres 7% of all net NFS acres

* (percent of Net NF acres)

Sierra Madre Mountains (SM) = 336,124 ac
Medicine Bow Mountains (MB) = 512,243 ac

Landforms and cover types differ among the four wilderness areas (Figure 9.1). Two major canyons in the North Platte watershed (Encampment River Canyon and Platte River Canyon), are included in the wilderness areas. High elevation spruce-fir forests and wetlands along both sides of the continental divide are found in the Huston Park Wilderness Area; the Savage Run Wilderness Area contains steep topography covered with lodgepole pine, spruce-fir and Douglas fir. The Platte River Wilderness contains a variety of lower elevation ecosystems including meadows, sagebrush steppe, Douglas fir forests and juniper woodlands. The Encampment River Canyon includes a long elevation gradient from spruce-fir forest to sagebrush ecosystems.

Cover type information is available for all wilderness lands, but only the Platte Ridge Wilderness Area has Stage II Inventory data which provides information on stand age. Structural stage data and old growth scorecard data exist for selected locations in all Wilderness Areas, usually in connection with acreages for old growth designation compliance with minimum Forest Plan old growth requirements within watersheds and Management Areas.

As a group, the four wilderness areas contain many ecosystems representative of the Medicine Bow and Sierra Madre Mountains. Although stand age information from Stage II inventory is not available for any wilderness except the Platte River Wilderness, inspection of aerial photos and field observation confirm that old forest exists in much of Huston Park, Savage Run and portions of the Encampment River Wilderness. Most forests in other portions of the Encampment River Wilderness and major areas of Platte Ridge, were initiated since 1850 in the wake of tie-hacking and mining activities.

Some ecosystems not represented, or underrepresented, in wilderness areas are moraines and kettleholes, other kinds of high elevation wetlands, high elevation virgin spruce-fir forest, ribbon forest, krummholz, alpine tundra, subalpine meadows and lower elevation climax lodgepole pine forest. Ponderosa pine and Douglas fir ecosystems and wetlands characteristic of the Sherman Mountains and Laramie Mountains are not found in wilderness areas of the Medicine Bow and Sierra Madre Mountains.

ROADLESS AREAS

Twenty-seven roadless areas were identified in the 1979 RARE II Inventory (Figure 9.2). Eleven RARE II areas are in the Sierra Madre Mountains, nine in the Medicine Bow Mountains, five in the Laramie Mountains, and three in the Sherman Mountains. A preliminary analysis of other areas which are roadless or undeveloped (minor roads) was done at the request of the Medicine Bow National Forest Leadership Team in fall of 1993 (Speas, 1993). One large additional roadless area (Fall Creek area southwest of Centennial) was identified. Numerous

smaller areas contiguous to RARE II roadless areas or wilderness were also identified. These will be considered in the roadless area analysis for Forest Plan Revision.

All or part of five of the 20 roadless areas in the Sierra Madre and Medicine Bow Mountains became wilderness (Table 9.2). These are: Huston Park - 02087; Encampment River - 02085; Platte River - 02080, and Savage Run Additions 02082 and 02083. Two others have particular uses. The Coon Creek Roadless Area (02085) is the site of the Coon Creek Project, and 02079 (Sheep Mountain) is a Federal Game Refuge.

Four of the 12 potential Research Natural Areas which were field-inventoried in 1994 (Threemile - 02072, Ribbon Forest, Moraine Ponds - 02074, Sheep Mountain - 02079, and Big Bear Canyon 02069) are in roadless areas. Two other potential RNA sites which were not inventoried in 1994 are in roadless areas (Deep Creek/Douglas Creek - parts of 02092 and Upper Deer Creek - 02068). The proposed Ashenfelder Basin RNA is in roadless area 02070.

Portions of roadless areas identified in the RARE II inventory have been entered for timber harvest prior to 1994, or were on the timber harvest schedule (1984 - 1997) in the 1985 Forest Plan. The roadless areas affected, acres harvested or proposed for harvest in the Forest Plan are listed in Table 9.3. By order of the Forest Supervisor in 1994, timber sales in roadless areas have been suspended pending the revision of the Medicine Bow National Forest Plan.

Table 9.2 Net acreages, and percentage, of RARE II and WILDERNESS(*) areas.
Note: RARE II inventory acreages (1979). Acreages for wilderness (WA) and for mountain ranges are net NFS acres from GIS. RAREII and WA are expressed as a percent of each mountain range. Sum of net NFS acres in Sierra Madre and Medicine Bow Mts = 848,367 ac.

SIERRA MADRE MOUNTAINS

RARE II Number	RareII Name	Present Acres	approx % RARE II ac	Wilderness Acres	approx % WA each range
02084	Bear Mtn.	13,310	4.0%		
02085	Coon Creek	11,330	3.0%		
02086	Encampment*	13,750	5.0%	10,400*	3%
02087	Huston Park*	65,850	20.0%	30,648*	9%
02088	Bridger Peak	7,100	2.0%		
02089	Mowry Peak	12,450	1.0%		
02091	Jack Creek	24,110	4.0%		
02092	Singer Peak	13,180	4.0%		
02093	Big Sandstone	6,710	2.0%		
02094	Little Sandstone	5,580	2.0%		
02095	Battle Creek	7,840	2.0%		
	TOTAL	181,210	54.0%	41,048	~12.0%

Sierra Madre Mts. (336,124 ac = net NFS ac)

MEDICINE BOW MOUNTAINS

02072	Rock Creek	19,860	4.0%		
02073	Pennock Mtn.	16,510	3.0%		
02074	Snowy Range	34,940	7.0%		
02075	Libby Flats	16,440	3.0%		
02079	Sheep Mountain	17,720	3.0%		
02080	Platte River*	36,320	7.0%	22,179	~4.0%
02082	Svg Run Addn.*	1,730	0.3%		
02083	Svg Run Addn.*	810	0.1%		
	Savage Run (all)			15,068	~3.0%
	TOTAL	127,760	25.0%	37,247	~6.0%

Medicine Bow Mts. (512,243 ac = net NFS ac)

Sum of RARE II ac for Sierra Madre and MB Mts.	308,970	36.0%		
Savage Run Wilderness (pre-1985 additions)	12,528	2.0%		
Sum of Wilderness ac (1995) for Sierra Madre and MB Mts.			78,295	~9.0%

Table 9.2 Continued.

RARE II Number	RareII Name	Present Acres	approx % RARE II ac	Wilderness Acres	approx WA
SHERMAN MOUNTAINS					
02076	Eagle Rock	6,520	12.0%	0	0
02077	Twin Mountain	7,600	14.0%	0	0
02078	Crow Creek	8,640	16.0%	0	0
Sherman Mts (55,408)		22,760	41.0%	0	0
LARAMIE MOUNTAINS					
02067	Deer Creek	13,080	7.0%	0	0
02068	Buffalo Peak	15,250	8.0%	0	0
02069	La Bonte Canyon	21,150	12.0%	0	0
02070	Laramie Peak	28,680	16.0%	0	0
02071	Eagle Peak	12,740	7.0%	0	0
Laramie Mts (178,161)		90,900	51.0%		
Sum of RARE II areas in Sherman and Laramie Mts.		113,660	49.0%	0	0

TABLE 9.3 Timber sales in roadless areas scheduled in the 1985 Forest Plan. Timber sales in Roadless Areas are presently suspended pending Forest Plan Revision.

Roadless Area	Area Number	Acres in Rare II Inventory	Sale Name and Date Sold	Approximate Acres Affected
Singer Peak	02092	11,851	Mill Creek (1988) Night Hawk (1995)	3200 5100 Total 8300 Percent of Rare II Affected: 70%
Jack Creek	02091	21,452	Strawberry Gulch (1995) Jack Creek Mine (1987)	3800 1900 Total 5700 Percent of Rare II Affected: 27%
Coon Creek	02085	7,899	Coon Creek (1988) Tie Camp (1996)	3000 4500 Total 7500 Percent of Rare II Affected: 95%

TABLE 9.3 Timber sales in roadless areas scheduled in the 1985 Forest Plan. Timber sales in Roadless Areas are presently suspended pending Forest Plan Revision.

Roadless Area	Area Number	Acres in Rare II Inventory	Sale Name and Date Sold	Approximate Acres Affected
Bear Mountain	02084	13,035	Bear Mtn. (1996)	3800 Percent of Rare II Affected: 29%
Platte River	02080	36,320	Platte Ridge (1989)	4500 Percent of Rare II Affected: 12%
Snowy Range	02074	34,428	Phantom Lake (1987) Fall Creek (1994)	1500 2500 Total 4000 Percent of Rare II Affected: 12%
Pennock Mountain	02073	16,510	Cedar Rank/Lee (1994)	6000 Percent of Rare II Affected: 36%

TABLE 9.3 Timber sales in roadless areas scheduled in the 1985 Forest Plan. Timber sales in Roadless Areas are presently suspended pending Forest Plan Revision.

Roadless Area	Area Number	Acres in Rare II Inventory	Sale Name and Date Sold	Approximate Acres Affected
Rock Creek	02072	19,860	Three Mile (1994) Trail Creek (1985) Seven Mile (1984)	5,100 2,500 700 Total 8300 Percent of Rare II Affected: 42%

Note: Timber sales included in this table are sales that have occurred since 1984 or are proposed sales in the Medicine Bow Forest Plan scheduled through 1997.

RESEARCH NATURAL AREAS

Research natural areas on National Forests and National Grasslands are called for by regulation, see 36CFR 219.25 and 36 CFR 251.23. RNAs provide examples of native ecosystems with minimal human manipulation or protect populations of threatened, endangered, or sensitive species. Further direction for RNAs is in Forest Service regulations. Research natural areas can now be designated by combined order of the Regional Forester and Director of the Research Station for Region 2, rather than by the Chief of the Forest Service. They are allocated to a specific Management Area which does not permit timber harvest, grazing, or other commodity uses. Recreation is allowed, provided the values of the RNA identified in the designation are not compromised by recreational activities.

The Regional Forester has made establishing additional RNAs a priority. A regional Research Natural Area Coordinator is based at the Rocky Mountain Forest and Range Experiment Station in Fort Collins. RNAs in Colorado, Nebraska, North Dakota, South Dakota, and parts of Wyoming are presented in Ryan et al. 1994.

There is one RNA on the MBNF. Fourteen other sites on have been field evaluated (1994) and will be considered for RNA land allocation during the Forest Plan revision process. Two additional sites are scheduled for field evaluation in 1996. Locations of the existing, proposed or potential RNA sites are in Figure 9.3)

The only RNA on the Medicine Bow National Forest is the 771 acre Snowy Range Research Natural Area established in 1936. It is adjacent to the former University of Wyoming Summer Science Camp, now operated as a recreational concession. The Snowy Range RNA contains high-elevation virgin spruce-fir forest, streams in the Libby Creek drainage, Swastika Lake and some high elevation wetlands.

Two large RNAs were proposed between 1988 and 1992. They are both awaiting completion of the Forest Plan Revision process for further action. The Savage Run RNA (approximately 1000 acres) is a lodgepole pine forest type within the Savage Run Wilderness Area. The decision to implement this RNA, called for in the 1985 Forest Plan, was made March 2, 1988 (Heath, 1988). An Establishment Record was prepared for this in 1989, but was not sent to the Region and Chief for final approval. The Ashenfelder Basin RNA represents the ponderosa pine forest type. An Environmental Assessment was prepared in 1992, and a public meeting held (December 4, 1992). Additional alternatives were developed by the ID Team in response to public concerns about recreational restrictions. Work on the Ashenfelder RNA was suspended in 1993 pending Forest Plan Revision.

The 12 potential RNA sites inventoried in 1994 were chosen to represent other ecosystem cover types besides spruce-fir, lodgepole pine, or ponderosa pine forests and to represent variations of community types and structure of the three major forest types. Where possible, potential RNA sites were located in vacant allotments or Wilderness Areas. Sixteen sites were identified by the RNA ID Team (von Ahlefeldt, Hines, Speas).Twelve sites were inventoried in 1994 (Jankovsky-Jones, 1994). Two other areas (Deep Creek/Douglas Creek - Sierra Madre; Upper Pass Creek - Medicine Bow Mountains; and the southern part of Sheep Mountain will be evaluated in 1996. Reno Hill-Bates - Laramie Mountains; Upper Deer Creek - Laramie Mountains) were dropped from the list. Detailed descriptions, maps, and photographs of the 12 potential RNAs are in Jankovsky-Jones et al. (1995). Descriptions of the Savage Run and Ashenfelder Basin Proposed Research Natural Areas are in the respective Establishment Report and Environmental Assessment.

The potential RNA sites were chosen to represent a wide spectrum of vegetation types representative of the MBNF, to represent unusual ecosystems such as ribbon forest), and to protect habitat for Threatened, Endangered, Candidate, and Sensitive species. Potential sites include watersheds with Colorado River cutthroat trout and wetlands for boreal toads and other amphibians. The RNAs contain bunchgrass ecosystems, shrub-steppe, juniper woodlands, limber pine and a variety of wetlands ranging from beaver ponds and wet meadows, to high elevation kettleholes and low elevation canyon bottoms. Forest types with old forest containing the Laramie columbine and clustered lady's slipper are also represented among the sites.

In addition to existing, proposed, and potential RNA sites, six areas currently are designated as Special Interest Areas (SIA) under the 1985 Forest Plan. The Ashenfelder Basin SIA is within the proposed Ashenfelder Basin RNA. The others are Cinnibar Park, Dry Park, Libby Flats Ribbon Forest, Medicine Bow Peak and a Gambel oak community near Battle Mountain. Special Interest Areas are exempt from timber harvest. Management emphases in Special Interest Areas are on perpetuation of vegetation or species of interest and educational uses.

Tables 9.4 and 9.5 lists acreage characteristics of all existing, potential and proposed RNAs. Major characteristics and acreages of existing, proposed, and potential RNAs are summarized in Table 9.5. Table 9.6 contains a list of the major upland and riparian vegetation types which are represented by this suite of existing, proposed and potential RNAs. A summary of major community types is in Table 9.7

Table 9.4 Existing (E), Proposed (Pr) and Potential (Po) Research Natural Areas. W = within Wilderness Area. FWR = within Federal Wildlife Refuge.

HIGH ELEVATIONS	MOUNTAIN RANGE		ACRES	
1. Snowy Range (Ex)	Medicine Bow Mts.		771	
2. Ground Moraine (Po)	Medicine Bow Mts.		1,260	
3. Ribbon Forest (Po)	Medicine Bow Mts.		4,316	
	SUM		6,347	
MEDIUM ELEVATIONS				
4. E. Fk. Encampment River (Po)	Sierra Madre Mts.		2,330	
5. Standard Park/Bogs (Po)	Sierra Madre Mts.		4,141	
6. Three Mile (Po)	Medicine Bow Mts.		8,788	
7. Platte Ridge and Canyon (Po)	Medicine Bow Mts.		12,432	W
8. Savage Run (Pr)	Medicine Bow Mts.		1,094	W
9. Many Ponds (Po)	Medicine Bow Mts.		885	
		SUM	29,580	
LOW ELEVATIONS				
10. Sheep Mountain (Po)	Medicine Bow Mts.		14,992	FWR
11. Ashenfelder Basin (Pr)	Laramie Mts.		7,000	
12. LaBonte Canyon (Po)	Laramie Mts.		3,425	
13. Big Bear Canyon (Po)	Laramie Mts.		2,553	
14. Old Maid's Draw (Po)	Laramie Mts.		973	
15. Battle Mountain (Po)	Laramie Mts.		716	
	SUM		29,659	

Total Existing, Proposed, and Potential RNA acres = 65,586 acres or 7.7% net MBNF NFS acres.

Table 9.5 Acreages of potential, proposed (*) and existing (**) research natural areas. Percent Net NFS Acres. Net MBNF acres = 1,081,936 acres. FWR = Federal wildlife refuge.

		Acres	Percent of area
SIERRA MADRE MOUNTAINS (336,124 ac)			
Battle Mountain		7,160	0.2%
Standard Park-Bogs		4,141	1.2% (In Wilderness)
E. Fork Encampment River		233	0.6%
	SUM	7,187	2.0%
MEDICINE BOW MOUNTAINS (512,243 ac)			
Ground Moraine		1,260	0.2%
Ribbon Forest		4,316	0.8%
Three Mile		8,788	1.7%
Many Ponds		885	0.1%
Platte Ridge		12,342	2.4% (In Wilderness)
Sheep Mountain		14,992	2.9% (FWR)
	SUM	42,583	8.3%
Savage Run*		1,094	0.2% (In Wilderness)
Snowy Range**		771	0.1%
	SUM	44,448	8.7%
LARAMIE MOUNTAINS (178,161 ac)			
Big Bear Canyon		2,553	1.4%
LaBonte Canyon		3,425	1.9%
Old Maids Draw		973	0.5%
	SUM	6,951	3.9%
Ashenfelder Basin*		7,000	3.9%
	SUM	20,902	11.7%
Total Acres RNA (Existing, Potential and Proposed) Outside Wilderness or Federal WL Refuge (FWR):			
Sierra Madre Mountains		3,046	0.9%
Medicine Bow Mountains		16,020	3.1%
Laramie Mountains		20,902	11.7%
	SUM	40,799	3.7% (net MBNF ac)
Add RNA areas in Wilder/WLR		32,569	
	SUM	73,366	6.8% (net MBNF ac)

Table 9.6 Major vegetation categories represented by existing, potential and proposed RNAs.

	AREA (See Table 9.5 for area numbers)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
UPLAND															
Coniferous Forest	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Deciduous Forest					x					x			x		x
Shrubland	x	x				x	x			x	x	x	x	x	x
Grassland/Forbland			x		x		x			x	x				x
RIPARIAN															
Coniferous Forest	x	x	x	x			x		x						
Deciduous Forest								x	x	x		x	x	x	
Shrubland	x	x	x			x	x	x	x	x	x				
Grassland/Forbland	x	x	x	x	x	x	x		x	x		x	x	x	

Table 9.7 Major plant communities represented in existing, potential and proposed research natural areas on the MBNF.

AREA

HIGH ELEVATIONS		LOW ELEVATIONS	
1. Snowy Range	Medicine Bow Mts.	10. Sheep Mountain	Medicine Bow Mts.
2. Ground Moraine	Medicine Bow Mts.	11. Ashenfelder Basin	Laramie Mts.
3. Ribbon Forest	Medicine Bow Mts.	12. LaBonte Canyon	Laramie Mts.
		13. Big Bear Canyon	Laramie Mts.
MEDIUM ELEVATIONS		14. Old Maid's Draw	Laramie Mts.
4. East Fk.Encampment	Sierra Madre Mts.	15. Battle Mountain	Sierra Madre Mts.
5. Standard Park	Sierra Madre Mts.		
6. Three Mile	Medicine Bow Mts.		
7. Platte Ridge	Medicine Bow Mts.		
8. Savage Run	Medicine Bow Mts.		
9. Many Ponds	Medicine Bow Mts.		

VEGETATION TYPE	AREA NUMBER 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
UPLAND FORESTS	
SPRUCE-FIR	
subalpine fir-Englemann spruce/grousewhortleberry	x x x x x x x x x
subalpine fir-Engelmann spruce/elk sedge	x x x x
ENGELMANN SPRUCE	
Englemann spruce/grouse whortleberry	x x x
SUBALPINE FIR	
subalpine fir-limber pine/common juniper	x
DOUGLAS FIR	
Douglas fir/common juniper	x
Douglas fir/antelope bitterbrush	x
Douglas fir/oregongrape	x
Douglas fir/kinnikinnik	x
Douglas fir/Idaho fescue	x
Douglas fir/elk sedge	x x x

Table 9.7 continued

VEGETATION TYPE	AREA NUMBER 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
LODGEPOLE PINE	
lodgepole pine/common juniper	x x x x x x x
lodgepole pine/russet buffaloberry	x x x x
lodgepole pine/grouse whortleberry	x x x x x x x x x
lodgepole pine/knnnikinnik	x
lodgepole pine/Oregon grape	x
lodgepole pine/elk sedge	x x x x x x x x
PONDEROSA PINE	
ponderosa pine/common juniper	x x x
ponderosa pine/mountain ninebark	x x
ponderosa pine/russett buffaloberry	x
ponderosa pine/bitterbrush	x
ponderosa pine/kinnikinnik	x
ponderosa pine/western snowberry	x
ponderosa pine elk sedge	x x x
ponderosa pine/bluebunch wheatgrass	x x
ponderosa pine/King spike fescue	x
ponderosa pine/Ross sedge	x
LIMBER PINE	
limber pine/common juniper	x x x
limber pine/kinnikinnik	x
limber pine/alpine clover	x
limber pine/Idaho fescue	x
QUAKING ASPEN	
quaking aspen/common juniper	x x x
quaking aspen/Saskatoon serviceberry-chokecherry	x
quaking aspen/kinnikinnik	x
quaking aspen/California brome	x
quaking aspen/timothy	x
RIPARIAN FORESTS	
SPRUCE-FIR	
subalpine fir-Engelmann spruce/arrrowleaf groundsel	x x
subalpine fir/Engelmann spruce/bluejoint reedgrass	x x x x
ENGELMANN SPRUCE	
Engelmann spruce/elkslip marsh marigold	x x
BLUE SPRUCE	
blue spruce-Engelmann spruce	x

Table 9.7 continued

VEGETATION TYPE	AREA NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
QUAKING ASPEN															
quaking aspen/water birch										x					
quaking aspen/Fendler meadowrue					x	x	x	x	x		x	x	x		
quaking aspen/western brackenfern					x		x					x			
NARROWLEAF COTTONWOOD															
narrowleaf cottonwood/sandbar willow-water birch							x					x			
narrowleaf cottonwood/moutain alder-redosier dogwood												x			
narrowleaf cottonwood/Kentucky bluegrass													x		
UPLAND SHRUBLANDS															
ROCKY MOUNTAIN JUNIPER															
Rocky Mountain juniper/big sagebrush												x			
Rocky Mountain juniper/antelope bitterbrush												x			
Rocky Mountain juniper/bluebunch wheatgrass							x								
SERVICEBERRY															
serviceberry/antelope bitterbrush/bluebunch wheatgrass															x
ANTELOPE BITTERBRUSH															
antelope bitterbrush-big sagebrush/Idaho fescue							x				x				
antelope bitterbrush-big sagebrush/bluebunch wheatgrass										x	x	x			
BIG SAGEBRUSH															
big sagebrush/Idaho fescue											x	x	x	x	x
big sagebrush/bluebunch wheatgrass							x			x					
MISCELLANEOUS SHRUBLANDS															
mountain mahogany/bluebunch wheatgrass										x					
American red raspberry							x								
American raspberry/Colorado columbine			x												
shrubby cinquefoil/tufted hairgrass		x													
RIPARIAN SHRUBLANDS															
mountain alder-water birch/willow						x				x	x				
mountain alder/redosier dogwood							x								
planeleaf willow/water sedge			x					x	x						
Geyer willow-willow/bluejoint reedgrass								x			x		x		
grayleaf willow-barrenground willow/tufted hairgrass		x	x												
Drummond willow/bluejoint reedgrass								x							
Booth willow/starry false Solomonseal							x								
Pacific willow											x				
sandbar willow/field horsetail							x								

Table 9.7 concluded

VEGETATION TYPE	AREA NUMBER														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FORBLANDS															
Parry clover/Ross avens			x		x										
UPLAND GRAMINOIDLANDS															
Idaho fescue/bluebunch wheatgrass							x				x				
bluebunch wheatgrass/Sandberg bluegrass										x	x				x
needle and thread/blue grama										x					
RIPARIAN GRAMINOIDLANDS															
tufted hairgrass/elkslip marshmarigold			x	x	x										
tufted hairgrass-sedge	x				x	x								x	
bluejoint reedgrass							x								
analogue sedge/tufted hairgrass										x					
beaked sedge			x												
water sedge/beaked sedge					x		x		x	x		x	x	x	
fewflower spikerush	x		x												
Drummond's rush/creeping sibbaldia						x									

OLD GROWTH

THE OLD GROWTH ISSUE

Management of landscapes for adequate acreages and arrangement of patches to insure viability of species associated with late seral or ""climax"" old forests has been a hotly debated issue in all parts of the country (Forest Planning 1982; Heinrichs 1983).

On NFS lands how much old growth, what for, where, and in what pattern has been largely left up to the discretion of individual national forest managers. Evolving old growth treatment in National Forest management plans that ""represent a signficant advance in management over existing plans"" is discussed in Thomas et al. 1988 (page 259). These advances include using wildlife habitat areas, wilderness areas, research natural areas, watershed protection areas, and specialized recreational areas as places to maintain old growth. Habeck (1988) recommended a connected system of closed-canopy old-growth forest as the best option for preservation of biological diversity on the Lolo National Forest in Montana. The Klamath Corridors proposal describes a similar concept for a group of California national forests (Pace 1991). In the early 1980s the BLM developed recommended guidelines to manage forests on BLM lands in Oregon. These guidelines were to create larger patches of forest in older seral stages and age classes, and to connect these areas, thereby facilitating communication among populations (Luman and Neitro 1980).

A legal argument that old growth forests are a necessary element of National Forest Management under the Multiple Use and Sustained Yield Act was presented in the journal *Environmental Law* (Juday 1978). A key management technique recommended for old growth was a network of old growth enclaves which could be on a scale within National Forests, or among National Forests and other lands.

NATIONAL AND REGIONAL POLICY AND ACTIONS

A 1989 memo from Forest Service Chief Dale Robertson to Regional Foresters and Research Station Directors provided a generic definition and description of old growth and a position statement on National Forest Old Growth Values:

> Old growth values shall be considered in designing the dispersion of old growth. This may range from a network of old growth stands for wildlife habitat to designated areas for public visitation.

> In general, areas to be managed for old growth values are to be distributed over individual National Forests with attention given to minimizing the fragmentation of old growth into small, isolated areas (Robertson 1989).

Region 2 Forester Gary Cargill and Research Station Director Hank Montrey founded a research intiative for old growth conifer forests in the Rocky Mountains as a cooperative effort among Research Station scientists and National Forests (Montrey and Cargill 1990). This was followed by 1) efforts to describe Region 2 old growth, 2) meetings, and 3) a briefing paper (Mehl 1991). A symposium entitled *Old Growth Forests in the Southwest and the Rocky Mountain Regions* was jointly held between Regions 2 and 3 in March 1992 (Kaufman et al. 1992).

MBNF FOREST PLAN MINUMUM REQUIREMENTS

The 1985 MBNF Forest Plan contains minimum acreage and patch size requirements for old growth stand retention for Management Areas within fourth-order watersheds (diversity units). These stands were called Designated Old Growth (DOG) and were removed from the suitable timber base. Different RIS codes were assigned to DOG inside or outside wilderness areas. A minimum of ten percent of each watershed was to be DOG patches (minimum of size of 30 acres). Within Management Areas 3A, 4B, and 9A 20 percent of the conifer potential natural vegetation (CPNV) forested area was to be in DOG. No guidelines for vegetation composition, pattern, connectivity or diversity among DOG stands appears in the 1985 Forest Plan.

Criteria for choosing DOG stands were developed after 1985. One of the results of this effort was creation of an Old Growth Scorecard adapted from methodology developed in Regions 1 and 6. Construction and use of this scorecard were presented at a symposium in 1989 (Raphael et al. 1992).

Old growth stands were designated between 1985 and the early 1990s using a combination of information from the Old Growth Scorecard, habitat structural stage characteristics, stand age data, recommendations from wildlife staff and negotiations within Districts among competing uses. Each District chose old growth stands independently. DOG stands were identified in the RIS database as codes 871 (DOG outside of wilderness areas) or 371 (DOG inside wilderness areas). The results of these efforts by 1992 was a collection of DOG stands consisting mainly of isolated small patches of DOG in the Medicine Bow and Sierra Madre Mountains. Through 1992, no old growth stands were designated

for the Sherman Mountains, presumably because there was no timber scheduled for harvest. In the Laramie Mountains, DOG was identified in the Ashenfelder Basin, portions of La Bonte Canyon, and other selected locations.

In addition to scoring old growth, the Old Growth Scorecard score was used for Forest Plan monitoring to count acres of forest meeting vertical diversity requirements with the assumption that high-scoring stands were also structurally complex. Because the number of forest canopy layers was not consistently recorded in the RIS database as a result inconsistencies in timber inventories, the scorecard score was used as a surrogate. Beginning in 1986, stands scoring 30 or higher were considered to have vertical diversity attributes meeting Forest Plan requirements. Amendment 4 (1989) changed the minimum score to 38 or higher. A discussion of the pros and cons of this method for monitoring vertical diversity is in the FY 1991 Monitoring Report.

MBNF OLD GROWTH EVALUATION

The FY 1991 Monitoring Report presented detailed tables of information from the RIS data base on the status of old growth in each diversity unit. Minimum acreage requirements for DOG were met in most diversity units in the Sierra Madre and Medicine Bow Mountains although in the Sierra Madre Mountains most DOG was within the Huston Park and Encampment River wilderness areas. Most watersheds of the Laramie Mountains and Sherman Mountains did not meet Forest Plan minimum requirements because old growth was not designated for many watersheds. The distribution of old growth in Management Areas within diversity units has never been presented in a monitoring report.

In 1993 an Old Growth Review Committee consisting of both Supervisor's Office and District personnel reviewed both the 1985 Forest Plan old growth patterns and guidelines, and the old growth product (DOG) which had developed between 1985 and 1992. Patch size, landscape position, vegetation characteristics, connectivity, stability of stand designation and relationship to old growth on the Routt and Arapahoe-Roosevelt National Forests in Colorado, were concerns identified by the Old Growth Review Committee.

The Committee found that most DOG in the Medicine Bow Mountains consisted of small patches of old growth in areas of highly fragmented forested age class patches from timber harvest (1950s -1990s). DOG stands in the Sierra Madre Mountains were concentrated in wilderness areas along the Contintental Divide and there was little information in the RIS database other than cover type for these stands.

Edge/interior ratios for numerous small patches of DOG growth resulted in little to no effective interior habitat. Some cover types had little or no representation in DOG. There was no overall comprehensive treatment of how old growth forest in general should relate to a age-fragmentation on a landscape scale and the Brush Creek and Laramie Districts were not coordinating their old growth programs at that time. Another problem was the "undesignation" and "redesignation" of old growth stands for reasons not based on old growth retention. In other words, old growth stands were often shifted around (during a six year period) for the purposes of other uses, thus an old growth system which changed slowly over a longer time frame but had stability in terms of decades or groups of decades was not being achieved using small, isolated, changeable patches.

Guidelines in the 1985 Forest Plan were considered to be a minimum by the Old Growth Review Committee. These minimums did not preclude arrangement of DOG into larger patches, or provision of connections among patches. Efforts to block up DOG into patches with less edge and more interior area, to provide special management considerations to areas adjoining DOG and to connect DOG patches had already been instituted by the Brush Creek District by 1992. The Old Growth Patch and Linkage System presented here is an extension of this concept and a result of the Old Growth Review Committee effort to create an integrated system of old growth forests for the Medicine Bow and Sierra Madre Mountain ranges within the MBNF.

OLD GROWTH LANDSCAPE ANALYSES

Old growth in this discussion is defined as forested stands with particular age, structure and vegetation characteristics. Although most of these stands are more than 200 years old, some may be less than 200 years old. Structure and vegetation characteristics may differ according to cover type. Old growth constitutes more acreage than DOG.

Analyses of old growth landscape patterns and characteristics for the Medicine Bow and Sierra Madre mountains were done in 1993-1994 with assistance from the Geography Department at the University of Wyoming (Baker 1994). These analyses supplemented District efforts to reorganize DOG into a logical system that met wildlife, TECS and other conservation objectives. Similar analyses are needed for the Sherman Mountains and Laramie Mountains.

Characteristics of both DOG stands and other forested stands in the RIS database were examined. Three criteria were used to identify stands with old growth characteristics: 1) stand age, 2) Old Growth Scorecard Score, and 3) complexity

of structural stage (4a, 4b, 4c or 5). Data for the Medicine Bow Mountains was good because most stands (both designated and not designated) had known stand ages from Stage II Inventory. Old Growth Scorecard Scores and or or structural stage ratings were also known for many stands whether they were designated or not. Information on stands in the Sierra Madre was not as good because there were substantial acreages of DOG within the Huston Park and Envampment River wilderness areas in the Sierra Madre Mountains which lacked any information on old growth score, age or structural stage. Only cover type was known.

Total forested area considered to be old growth was estimated within each Biodiversity Unit for the Medicine Bow and Sierra Madre Mountains from RIS data (Baker 1994). GIS map layers constructed from the RIS database were intersected on the GIS system to produce a map of cumulative estimated old growth forests based on stands with any or all of the following characteristics:

1. The stand origin date was before 1800.

2. If the stand origin date was after 1800, then the structural stage must be 4A, 4B, 4C or 5 (mature or overmature with various canopy closures).

3. Any stand scoring 38 or more on the Old Growth Scorecard not already identified by criteria 1 or 2.

Multiple criteria were used because not all stands in the RIS database had values for all three characteristics (age, scorecard score and habitat structural stage). Use of three criteria identified a broader suite of old growth stands than any one criterion. Thus stand age, and habitat values associated with forest structure were used in concert to identify where old growth was located on the MBNF. While these criteria did not identify not every acre of old growth such as aspen, lower elevation lodgepole pine types or small stature very old stands on environmentally stressed sites, this method is believed to give a reasonable estimate of how much old growth exists and where it found in each watershed.

Maps showing location of old growth stands which qualified under the multiple criteria and tables of acreages were prepared in 1994 and 1995. Interior area of old growth patches was measured using four different edge effect zones of 0, 60, 120 and 180 meter depths for each patch. The analysis also demonstrated relationships of patch numbers, patch sizes and patch densities. A full discussion is in Baker (1994).

Table 9.8 Acreages of interior forest for spruce-fir (TSF), lodgepole pine (TLP), Douglas fir (TDF) and aspen (TAA) in each Biodiversity Analysis Unit and Area. The left-hand columns are acres of interior old-growth forest area with no edge effect zone, the right hand columns are acres of interior old growth forest with a 60 meter edge effect zone (from Baker 1994 Table A-23).

SIERRA MADRE		0	0	0	0	SUM	60	60	60	60	SUM
SM-NW	BDU	TSF	TLP	TDF	TAA		TSF	TLP	TDF	TAA	
Savery Creek	1	1371	3754	0	454	5579	1025	1772	0	177	2974
Dirtyman Creek	2	71	3004	0	895	3970	46	1854	0	477	2377
Big Sandstone Creek	3	2643	10577	141	3559	16920	1627	2050	0	109	3786
Jack Creek	13	2194	4131	0	447	6772	2050	0	109		2159
North Spring Creek	14	2396	4739	0	254	7389	1494	1635	0	96	3225
South Spring Creek	15	3040	1818	0	136	4994	2223	697	0	43	2963
Cow Creek	16	2034	2355	0	38	4427	1235	1078	0	4	2317
	Sum	13749	30378	141	5783	50051	9700	9086	109	906	19801
		0	0	0	0	SUM	60	60	60	60	SUM
SM-SW	BDU	TSF	TLP	TDF	TAA		TSF	TLP	TDF	TAA	
Little Sandstone Creek	4	39	1484	43	4878	6444	7	575	24	3185	3791
Big Gulch	5	118	0	0	622	740	66	0	0	328	394
E. Sweetwater Gulch	6	8	97	0	0	105	0	26	0	0	26
Lower Battle Creek	7	3	168	0	3089	3260	0	80	0	2037	2117
Cottonwood Creek	8	14	66	0	1223	1303	12	44	0	640	696
Roaring Fk LSR	9	2671	1603	0	2776	7050	1835	1095	0	2162	5092
N. Fk LSR	10	8876	3919	0	4130	16925	7303	3129	0	2855	13287
Upper Battle Creek	11	2673	447	0	2158	5278	1787	282	0	1430	3499
W. Fork Battle Creek	12	1635	2214	0	3177	7026	1053	1557	0	2194	4804
	Sum	16037	9998	43	22053	48131	12063	6788	24	14831	33706
		0	0	0	0	SUM	60	60	60	60	SUM
SM-Enc. River	BDU	TSF	TLP	TDF	TAA		TSF	TLP	TDF	TAA	
N. Fk Encampment River	17	2076	1717	0	186	3979	1346	830	0	45	2221
S. Fk. Miner Creek	18	2856	3394	0	297	6547	2017	1870	0	152	4039
Hog Park Creek	19	2830	4692	0	175	7697	2442	3622	0	159	6223
Encampment River Canyo	20	1642	6692	0	59	8393	1449	4878	0	54	6381
Billie Creek	21	835	2159	0	94	3088	687	1246	0	38	1971
E. Fk Encampment River	22	2361	5289	0	0	7650	1371	3644	0	0	5015
	Sum	12600	23943	0	811	37354	9312	16090	0	448	25850
		0	0	0	0	SUM	60	60	60	60	SUM
SM-SE	BDU	TSF	TLP	TDF	TAA		TSF	TLP	TDF	TAA	
Beaver Creek	23	98	4016	0	186	4300	67	2211	0	36	2314
Middle Fk Big Creek	24	498	3773	26	85	4382	203	1381	9	7	1600
Bear Creek	25	0	1858	106	219	2183	0	881	46	109	1036
S. Fk Big Creek	26	0	822	191	72	1085	0	265	66	12	343
	Sum	596	10469	323	562	11950	270	4738	121	164	5293
SIERRA MADRE TOTALS		42962	74788	507	29209	147486	31345	36702	254	16349	84650

Table 9.8 continued

SNOWY RANGE

SRN-West	BDU	0 TSF	0 TLP	0 TDF	0 TAA	SUM	60 TSF	60 TLP	60 TDF	60 TAA	SUM
S. Fk. Lake Creek	27	628	1822	0	121	2571	314	1104	0	88	1506
N. Cedar Creek	28	1068	1943	0	765	3776	592	1464	0	604	2660
Rankin Creek	29	1595	2258	0	531	4384	1273	1494	0	419	3186
Pass Creek	30	4034	2981	0	61	7076	2630	1544	0	28	4202
S. Cedar Creek	31	1769	134	0	587	2490	1166	749	0	405	2320
Lower N. Brush Creek	32	1176	2351	0	114	3641	377	913	0	38	1328
Upper N. Brush Creek	33	5769	1127	0	0	6896	3031	715	0	0	3746
S. Brush Creek	34	4484	1492	0	31	6007	2664	809	0	7	3480
Lower Brush Creek	35	504	1767	0	297	2568	168	908	0	13	1089
N. Cottonwood Creek	36	49	23	98	82	1252	15	1127	56	40	1238
Middle French Creek	37	2619	1828	10	38	4495	1130	730	3	8	1871
Upper S. French Creek	38	4946	2929	0	122	7997	3244	1950	0	75	5269
Lower S. French Creek	39	538	1678	162	324	2702	260	833	100	176	1369
	Sum	29179	22333	270	3073	54855	16864	14340	159	1901	33264

SRN-Northeast	BDU	0 TSF	0 TLP	0 TDF	0 TAA	SUM	60 TSF	60 TLP	60 TDF	60 TAA	SUM
Fourmile Creek	60	942	5178	0	62	6182	588	3548	0	24	4160
North Rock Creek	61	4829	4553	177	0	9559	3012	2572	159	0	5743
South Rock Creek	62	4649	5040	0	0	9689	3126	3337	0	0	6463
W. Medicine Bow R	63	1696	1807	0	0	3503	765	943	0	0	1708
Upper Medicine Bow River	64	2550	63	0	0	2613	1570	22	0	0	1592
Lower Medicine Bow River	65	1862	1342	0	27	3231	870	66	0	0	936
East Medicine Bow River	66	1496	1673	0	48	3217	606	715	0	7	1328
Wagonhound Creek	67	228	1744	0	13	1985	80	640	0	4	724
	Sum	18252	21400	177	150	39979	10617	11843	159	35	22654

SRN- East Central	BDU	0 TSF	0 TLP	0 TDF	0 TAA	SUM	60 TSF	60 TLP	60 TDF	60 TAA	SUM
South Fork	56	393	3237	486	49	4165	197	1749	323	10	2279
Middle Fork	57	3726	7538	183	53	11500	2515	5577	126	38	8256
North Fork	58	8168	5016	25	461	13670	5536	2676	7	86	8305
Mill Creek	59	818	1806	0	376	3000	458	906	0	180	1544
	Sum	13105	17597	694	939	32335	8706	10908	456	314	20384
SNOWY RANGE NORTH TOTAL		60536	61330	1141	4162	127169	36187	37091	774	2250	76302

Table 9.8 concluded

SNOWY RANGE SOUTH

SRS-Wilderness	BDU	0 TSF	0 TLP	0 TDF	0 TAA	SUM	60 TSF	60 TLP	60 TDF	60 TAA	SUM
Mullen Creek	40	4472	3427	194	163	8256	2774	2127	125	50	5076
Cottonwood Creek	41	333	1806	577	19	2735	195	1150	250	1	1596
Platte River	42	86	2737	979	163	3965	31	1199	451	38	1719
	Sum	4891	7970	1750	345	14956	3000	4476	826	89	8391

SRS-Central	BDU	0 TSF	0 TLP	0 TDF	0 TAA	SUM	60 TSF	60 TLP	60 TDF	60 TAA	SUM
Pelton Creek	43	763	5499	0	246	6508	318	2587	0	86	2991
Lower Douglas Creek	44	115	1748	100	10	1973	22	721	52	2	797
Mowberg Creek	45	118	1900	0	0	2018	47	834	0	0	881
Lake Creek	46	286	2662	0	0	2948	91	1006	0	0	1097
Muddly Creek	47	290	3177	0	0	3467	140	1339	0	0	1479
Middle Douglas Creek	48	1572	5155	0	0	6727	954	2705	0	0	3659
Devils Gate Creek	49	241	1243	0	4	1488	60	452	0	0	512
Upper Douglas Creek	50	2125	3251	0	0	5376	1280	1110	0	0	2390
	Sum	5510	24635	100	260	30505	2912	10754	52	88	13806

SRS-Southeast	BDU	0 TSF	0 TLP	0 TDF	0 TAA	SUM	60 TSF	60 TLP	60 TDF	60 TAA	SUM
Boswell Creek	51	278	2549	44	148	3019	100	801	3	18	922
Bear Creek	52	100	2257	317	289	2963	62	588	146	35	831
Lake Owen Creek	53	362	3777	203	260	4602	129	1532	67	47	1775
Johns Creek	54	0	1996	0	12	2008	0	1276	0	11	1287
Buckeye Creek	55	30	1075	0	0	1105	5	673	0	0	678
	Sum	770	11654	564	709	13697	296	4870	216	111	5493

SNOWY RANGE SOUTH	Sum	11171	44259	2414	1314	59158	6208	20100	1094	288	27690
SNOWY RANGE TOTAL	Sum	71707	105589	3555	5476	186327	42395	57191	1868	2538	103992
LOWER BOW TOTAL	Sum	114689	180377	4062	34685	333813	73740	93893	2122	18887	188642

The landscape analysis showed substantial differences in both overall acreage of old growth and interior area when the edge effect was applied (Figure 9.4, Table 9.8). Even a modest 60 meter (approximately 190 feet) edge effect, decreased the acres of interior old growth forest 30-70 percent in some watersheds where remaining old growth forests was highly fragmented by timber harvests of the past half century (Table 9.9). Configuration of harvested stands often causes edge effects to overlap so the amount of interior forest becomes zero in smaller patches. The amount of interior old growth forest was small and disconnected in many watersheds. In some watersheds less than five percent of the old growth forest was in patches larger than five acres. The fragmentation effect analysis was conservative because edges associated with roads were not counted because the GIS road layer was not available.

Table 9.9 Reduction of interior forest area for selected watersheds with a 60 meter edge effect applied to existing young forest patches. (Baker 1994). (Appendix 11)

BDU	Acres No edge effect	Acres 60m edge effect	Percent reduction
Sierra Madre			
13 Jack Creek	6,772	2,159	68%
14 North Spring Creek	7,389	3,225	56%
21 Billie Creek	3,088	1,971	36%
Snowy Range			
32 Lower North Brush Cr.	3,641	1,328	64%
33 Upper North Brush Cr.	6,896	3,646	46%
35 Lower Brush Creek	2,568	1,089	58%
37 Middle French Creek	4,495	1,871	58%
63 West Medicine Bow River	3,503	1,708	51%
65 Lower Medicine Bow River	3,231	936	71%
45 Mowberg Creek	2,018	881	56%
48 Middle Douglas Creek	6,727	3,659	46%
49 Devils Gate Creek	1,488	512	65%
50 Upper Douglas Creek	5,376	2,390	56%

ENHANCEMENT OF MINIMUM MBNF OLD GROWTH REQUIREMENTS

Work by the Brush Creek and Laramie Ranger Districts prior to 1993, analysis by the Old Growth Review Committee in 1993-94, and the GIS analysis of forest-wide old growth enabled the development of ways to enhance the minimum MBNF old growth requirements of the 1985 Forest Plan to provide a more stable, more functional old growth pattern incorporating DOG into a landscape level old growth system.

The Brush Creek District had already designed an old growth patch and linkage system by 1992. This was the concept of the patch and linkage system. The Brush Creek old growth ID Team assessed the configuration and composition of old growth in the northwestern part of the Medicine Bow Mountains (Snowy Range North-West BDA and part of Snowy Range North - East BDA). They were interested in developing an old growth system which would function better for wildlife species than the isolated small patches of designated old growth in a landscape which had a high degree of forest age fragmentation due to strip cutting, partial cutting and other harvest methods which began in the 1950s. The post-World War II harvest pattern was not designed to retain large patches of old growth interior forest. Rather, it was designed to harvest most suitable timber stands and place them into a silvicultural rotation system.

Many designated old growth stands on the Brush Creek District were in leave strips of strip cut areas, were very small, or had a high ratio of edge to interior (which often compromised the value of the stand as interior forest). Also, because the old growth scorecard was weighted heavily toward stands with multiple species, multiple layers, and dead and down woody material (i.e. late seral mixed conifer or spruce-fir forests) other kinds of old forest (those on poor or severe sites, single-storied old lodgepole pine forests, those which had open understories maintained by fire, or deciduous forests) scored poorly and were not well-represented among designated sites.

Jerry Mastel, Brush Creek District Ecologist, formed an ID Team in the early 1990s to reconfigure the designated stands by blocking them into larger groups and placing designated patches near wetlands, adjacent to areas of old forest unsuitable for timber harvest because of soil constraints, or where the old growth sites fulfilled specific needs identified for wildlife habitat. This was an improvement but still produced a pattern of disconnected old growth patches, many of which were still quite small, in a highly fragmented matrix of what had been continuous-canopy forest a half-century ago.The

Laramie District staff began designing of and old growth patch and linkage system with the preparation of the White-Swan Holmes Timber sale planning as a nucleus, and had already begum to "block" up scattered DOG into larger patches. Maps and data from the old growth landscape analysis (Baker 1994) enabled the design of linkages to connect patches within and between these Districts in the Medicine Bow Mountains, and

the development of a basic landscape design for old growth in the Sierra Madre Mountains which would include aspen and lower elevation forests outside the wilderness areas.

The problem of fragmented old growth stands in an age-fragmented landscape was resolved by linking many DOG patches together into an Old Growth Patch and Linkage system. The linkages between patches, and areas around isolated patches, consisted of stands of old forest, stands of younger forest and non-forested stands associated with old growth ecosystems (meadows, talus, riparian areas). Nearby forested stands, are called ""non-designated old growth"" (NDOG) to distinguish them from designated old growth specified in the 1985 Forest Plan. Non-designated forested old growth stands remain in the suitable timber base, although some stands are on unsuitable sites and are not in the suitable timber base for that reason. NDOG stands are identified in the RIS database for special consideration but do not have any official DOG status under the 1985 Forest Plan. Official incorporation of the non-designated old growth concept (with management guidelines) into the Forest Plan is an old growth management option to discuss during the Forest Plan Revision. Special standards and guidelines applicable to NDOG areas need to be developed to suit the landscape characteristics of the NDOG stands in the Old Growth Patch and Linkage System.

THE OLD GROWTH PATCH AND LINKAGE SYSTEM

The Old Growth Patch and Linkage System concept embeds isolated patches of DOG into larger landscape scale system which is managed for old growth characteristics. This does not preclude timber harvest in non-designated stands, but brings attention to stands associated with DOG to help maintain or restore old growth landscape values. Very long rotations and light partial cutting methods are two techniques which might be used. Management guidelines for the Old Growth Patch and Linkage System could be developed during the Forest Plan revision. At present, management of such stands is dependent on District policies. The concept of larger patches of old grwoth, and linkages aming them, follows current planning guidance from the Region and is congruent with current concepts of Conservation Biology (Hemstrom 1993; USDA Forest Service April 1994; Grumbine 1990; Hudson 1991).

Current Regional direction recommends larger old growth patches (500 - 2000 acres) and connections among them. Hemstrom (1993) referred to this idea as a ""reserve and connection"" system and considered it to be a ""safety net"" which was appropriate both in previously fragmented systems and forests not yet entered for timber harvest. In forest areas which are presently fragmented, connectivity provides a way to maintain existing continuity and provides management stablity so that younger areas can become part of a logical system. For unentered areas identification of stands with good old

growth characteristics and old growth values will help ensure their continuation when harvest occurs. Identification of old growth reserves and connections in maps and data bases promotes recognition of old growth as a National Forest resource.

An Old Growth Patch and Linkage System for the Medicine Bow and Sierra Madre Mountains is presented in this report (Figures 9.4-9.9). This is the result of several years work by District Staff and by the Old Growth Review Committee. The concept has the support of District Rangers administering the Brush Creek-Hayden and Laramie Ranger Districts. Evaluation of speciific sites, blocking of stands into larger groups, augmentation of isolated designated old growth patches with non-designated stands, and design of linkages was done for the Medicine Bow Mountains by the Laramie and Brush Creek Districts during the early 1990s in conjunction with timber sale planning and other District Activities. An Old Growth Patch and Linkage system for the Sierra Madre is in an earlier stage of development than for the Medicine Bow Mountains due to personnel changes and limited time for interdisciplinary discussion.

The Old Growth Patch and Linkage System landscape configurations presented below are site specific. The system was developed within constraints of existing stand ages and condition, Management Area considerations, position of DOG stands, known TECS habitat and other wildife habitat considerations.

A series of maps shows the configuration of the Old Growth Patch and Linkage System for the Medicine Bow and Sierra Madre Mountains and its relationship to various land uses and vegetation classifications (Figures 8.4-9.9). The Old Growth Patch and Linkage System is a network of stands which are either DOG or NDOG areas. which Because this is an ecosystem concept, some non-forested areas are embedded in the system.

Changes to this system will occur as time goes on and new information or stochastic events suggest rational changes to the system. Forest age fragmentation and the legacy of stand age and structure from the 1860s to the early 1900s create severe constraints to the choices of where to place old growth so that it is functional as wildlife habitat and provides aesthetic and other values. Choices for larger patches outside of wilderness areas still exist on the Sierra Madre, but are extremely limited in the Medicine Bow Mountains. This system was designed with recognition of existing spatial and land use constraints accumulated over the past century.

The Old Growth Patch and Linkage System system was designed to connect the Wilderness Areas (parallel hatching) with current roadless areas, and existing, potential or proposed Research Natural Areas. It was also designed to meet specific habitat needs for several R-2 sensitive species (especially northern goshawks and other forest raptors, wood frogs and boreal toads) and to accommodate seasonal movements for some

species, including big game. Riparian areas (Management Area 9A) have been delineated by the Brush Creek District and are shown in blue. Few 9A areas have been identified by the Laramie District or Hayden District, so they do not appear on the maps (Figure 9.5 a,b).

In the Medicine Bow Mountains (Figure 9.5a), the connections come near Sheep Mountain Federal Game Refuge, but do not join entirely because the intervening area is not forested. In the Sierra Madre Mountains most designated old growth is in wilderness areas. Linkages of NDOG form connections among the Wilderness Areas, old forest in the northwestern area and areas contiguous with the Mount Zirkel Wilderness on the Routt National Forest in Colorado. Patch sizes in the Sierra Madre are larger than in the Medicine Bow Mountains because there is less fragmentation from timber harvest.

Stand age, structural stage, and Old Growth Scorecard attributes of the Old Growth Patch and Linkage System are in Figures 9.6 - 9.8. Most stands are older than 1850, but there is a mix of stand ages. Complex structural stages are well-represented. Most stands have Old Growth scores above 30. The more complex stands of higher elevations containing spruce-fir or late seral lodgepole pine forests often score higher than 46. Stands scoring 30-37 often include single-storied lodgepole stands with open understories. These are also a valuable old-growth type and provide excellent habitat for northern goshawks. Structural stage or stand age is known for most areas lacking scorecard data. Note that most of the designated old growth in the Encampment River Wilderness has either structural stage or scorcard data or both, but much of the Designated old Growth in the Huston Park Wilderness has neither.

Relationships of the Old Growth Patch and Linkage System to timber suitability classification and other categories are shown in Figure 9.9. Very little of the suitable timber base has been identified as NDOG for the Old Growth PAtch and Linkage System. Acreages for each category are in Table 9.10. The patch of NDOG in the suitable timber base in the Sierra Madre Northwest Biodiversity Area is associated with several roadless areas (Figure 9.9). Part of this patch has been identified as a potential Research Natural Area which are scheduled for field-evaluated in 1996. The large patch of suitable timber in the Encampment River Biodiversity Analysis Area is mostly the East Fork of the Encampment River which is the control area for the Coon Creek Project. This is also under consideration for a potential Research Natural Area. The patch southeast of the Coon Creek project along the State Line is important because it is adjacent to uncut forest on the Routt National Forest. Most of the forested area on the Colorado side has been clearcut harvested. Old growth aspen forests are also included in the Sierra Madre portion of the Old Growth Patch and Linkage System.

A variety of cover types is represented in the Old Growth Patch and Linkage System (Figure 9.10). Relationships of patches and linkages to riparian areas are varied. Some riparian areas are within linkages, in other areas linkages follow or cross ridges, connecting watersheds. The linkages connect existing, proposed, and potential RNA sites, roadless areas, and Wilderness Areas.

Table 9.10 Attributes of the Old Growth Patch and Linkage System (approximate acres).

Attributes	Acres Sierra Madre Mts.	Acres Medicine Bow Mts.
Designated OG		
Spruce-fir	29,333	26,000
Lodgepole pine	19,305	26,072
Other conifer	949	374
Aspen	1504	958
SUM DOG	48,091	53,404
Non Designated OG		
Spruce-fir	18,579	18,488
Lodgepole pine	39,074	50,526
Other conifer	595	584
Aspen	17,320	1524
SUM major cover types NDOG	20,568	71,122
Non Designated OG		
Suitable timber (uncut and partial cut)	50,457	54,141
Unsuitable - forested	38,570	32,279
SUM forested NDOG	89,027	86,420
Not forested	13,325	11,699
SUM NDOG	102,352	98,119

Spatially isolated old-growth units which are islandlike and lack connections to other old-growth or mature seral stands are likely to have less value to biological diversity preservation than a connected system. The Old Growth Patch and Linkage Syytem is a logical resource management and planning tool which can coordinate and integrate old growth with other management concerns and choices.

Wilderness areas, roadless areas, research natural areas, designated old growth and a system of closed-canopy forests connected through a variety of landscape contexts appears to be a functional way to enhance the options for maintaining old growth aspects of biological diversity on the MBNF. The Old Growth Patch and Linkage System as presented in this report is a landscape-wide foundation for further discussion and refinement during Forest Plan Revision and Project Planning.

SUMMARY

Land uses for wilderness areas, roadless areas and research natural areas have been evolving under NFS management since the RAREII inventories over 25 years ago. All three of these areas may contain substantial old growth forests. Old growth is not harvested for timber in wilderness or RNA's, but may be managed in specific ways to maintain old growth characteristics. On the MBNF, some roadless areas have been entered for timber harvest since 1985, but currently, timber sale planning and harvests are not occurring in roadless areas by order of the Forest Supervisor.

Forests older than 200 years, of both spruce-fir and lodgepole types, have been heavily strip or block clearcut, partial cut or group shelterwood cut mainly since 1950. Large areas of uncut old growth are found in the Huston Park and Savage Run Wilderness areas. The Platte River Wilderness and Encampment River Wilderness has smaller areas of old growth because of fires and logging between about 1850 and 1910. Many roadless areas also contain forests older than 200 years.

Fragmentation of older forests has occurred because of roads, timber harvest (age fragmentation) and natural events such as fires, blowdowns and landslides. The Old Growth Patch and Linkage System was developed to provide a landscape-scale miminum for perpetuation of old-growth biological diversity in the context of wilderness, RNA's, roadless areas, and other man-created and natural frameworks.

LITERATURE CITED

Baker, W.L. 1994. landscape structure measurements for watersheds in the Medicine Bow National Forest using GIS analysis. Contract Medicine Bow National Forest and University of Wyoming. Laramie, WY.

Forest Planning. 1982. Old growth: new directions for management. (A collection of articles). Journal of the Nationwide Forest Planning Clearinghouse. March, 1982 pages 3-22.

Grumbine, R.E. 1990. Viable populations, reserve size and federal lands management: a Critique. Conservation Biology 4(2):127-134.

Habeck, J.R. 1988. Old-growth forests in the Northern Rocky Mountains. Natural Areas Journal 8(3):202-211.

Harris, L.D.; Maser, C.; McKee, A. 1982. Patterns of old growth harvest and implications for Cascades Wildlife. 47th North American Wildlife Conference Transactions Wildlife Management Institude Washington, D.C. pages 374-392.

Heath, G. 1988. Letter to the Regional Forester regarding the proposed Savage Run Reseach Natural Area. File 4060. Medicine Bow National Forest. March 2, 1988 Laramie, WY.

Heinrichs, J. 1983. Old growth comes of age. Journal of Forestry December pages 776-779.

Hemstrom, 1993. Presentation on ecosystem management at the Region 2 botany, fish and wildlife meetings. Jan., 1993. Denver, CO.

Hudson, W.E. 1991. *Landscape linkages and biodiversity*. Island Press Washington, D.C.

Jankovsky-Jones, M.; Jones, G.P; Fertig, W. 1995. Ecological evaluations for potential research natural areas. (Twelve separate Reports). Prepared for the Medicine Bow National Forest by the Wyoming Natural Diversity Database. Laramie, WY.

Juday, G.P. 1978. Old growth forests: a necessary element of multiple-use and sustained-yield national forest management. Environmental Law 8:497-522.

Kaufman, M.R.; Moir, W.H.; Bassett, R.L. 1992. Old growth forests in the Southwest and Rocky Mountain Regions. USDA Forest Service General Technical Report RM-213.

Luman, I.D.; Nietro, W.A. 1980. Preservation of mature forest seral stages to provide wildlife habitat diversity. Transactions of North American Wildlife and Natural Resources 45:271-277.

Medicine Bow National Forest. 1983. Roadless area descriptions: 1976-1983. Compiled from: 1976 Roadless Area Descriptions; 1978 DEIS RAREII Review; 1983 DARN (Development

in Roadless Nonwilderness Report); 1983 MBNF Planning Database and 1983 District Ranger Updates). MBNF Laramie, WY.

Medicine Bow National Forest. 1989. Savage Run Research Natural Area Establishment report. (Prepared by Barry Johnston, Regional Office). Lakewood, CO.

Medicine Bow National Forest. 1992. Ashenfelder basin environmental assessment. 1992. Medicine Bow National Forest. Laramie, WY.

Mehl, M. 1991. Old-growth briefing paper. Rocky Mountain Region. Lakewood, CO.

Montrey, H.M.; Cargill, G.E. 1990. Cooperative strategy for old growth research. Memo to Forest Supervisors. File 2410/4000. USDA Forest Service Lakewood, Colorado.

Pace, F. 1991. The Klamath Corridors: preserving biodiversity in the Klamath National Forest. IN: Hudson, W.E. Landscape Linkages and Biodiversity. Island Press, Washington, D.C.

Raphael, M.; Marquardt, S.L.; Barrett, R.H. 1992. Evaluating stand conditions to support integrated silvicultural presciptions for timber and wildlife: Snags and Old Growth IN: Habitat Futures: Integrating Timber and Wildlife in Forest Landscapes: A Matter of Scale. Symposium Proceedings (1989) Ed. by Nyberg, J.B. and W.B. Kessler. British Columbia Ministry of Forests.

Robertson, F.D. 1989. Old growth management: Memo to Regional Foresters and Station Directors. File 2410. October 11, 1989. Washington, D.C.

Ryan, M.G.; Joyce, L.A.; Andrews, T.; Jones, K. 1994. Research Natural Areas in Colorado, Nebraska, North Dakota, South Dakota and Parts of Wyoming. USDA Forest Service General Technical Report RM-251. Fort Collins, CO.

Speas, C. 1993. Preliminary roadless area analysis, forest plan revision effort. Pewraonal communication. MBNF, Laramie, WY.

Thomas, J.W.; Ruggiero, L.F.; Mannan, R.W.; Schoen, J.W.; Lancia, R.A. 1988. Management and conservation of old-growth forests in the United States. Wildlife Society Bullein 16:252-262.

USDA Forest Service. 1994. Forest plan revision desk guide. Rocky Mountain Region. April, 1994. Lakewood, CO.

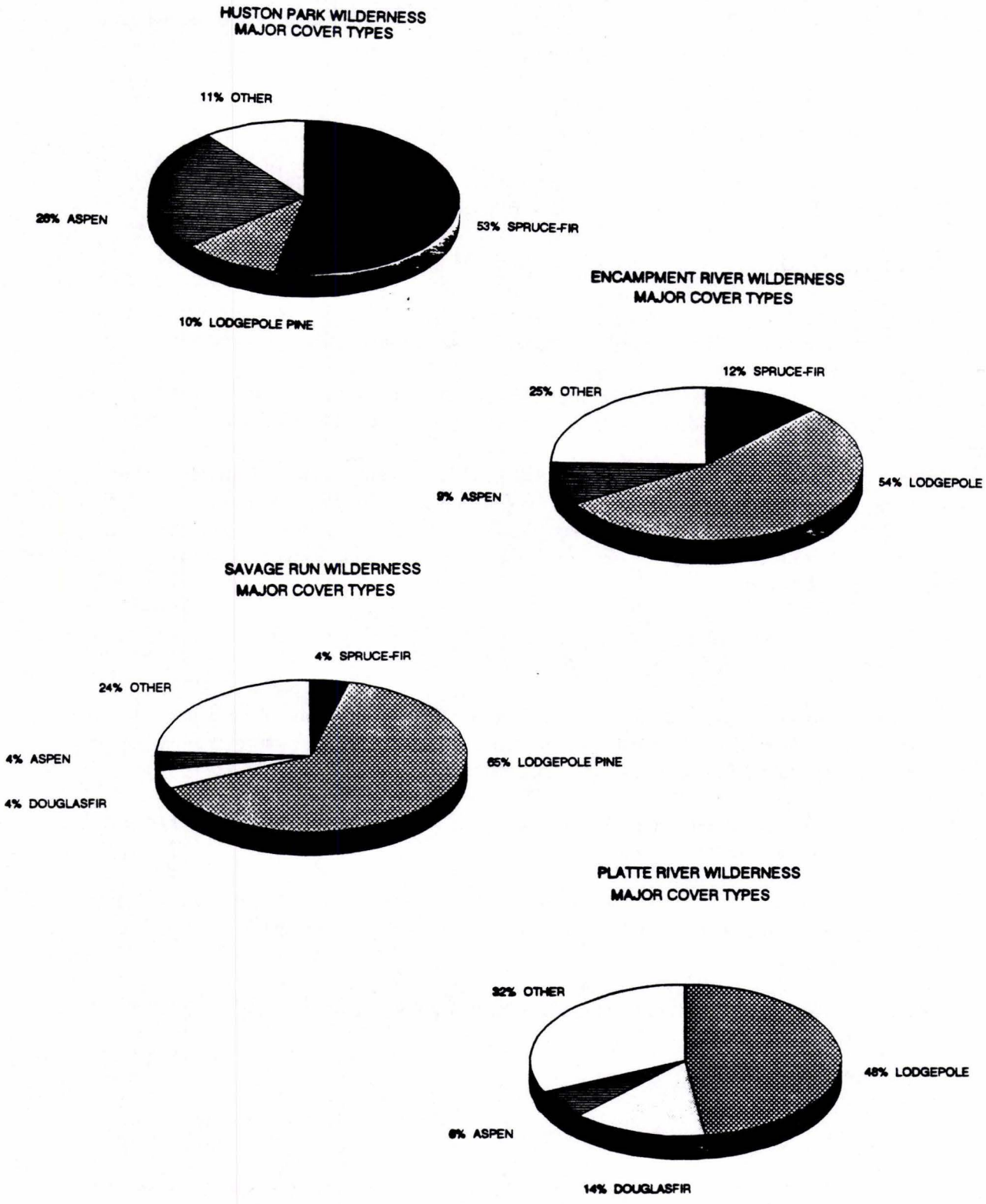


FIGURE 9.1 Major cover types of Wilderness Areas.

NUMBER	AREA NAME
02067	Deer Creek
02068	Buffalo Peak
02069	LaBonte Canyon
02070	Laramie Peak
02071	Eagle Peak
02072	Rock Creek
02073	Pennock Mt.
02074	Snowy Range
02075	Libby Flats
02076	Eagle Rock
02077	Twin Mt.
02078	Crow Creek
02079	Sheep Mt.
02080	Platte Riv.
02082	Savage Run Add.
02083	Savage Run Add.
02084	Bear Mountain
02085	Coon Creek
02086	Encampment Riv.
02087	Huston Park
02088	Bridger Peak
02089	Mowry Peak
02091	Jack Creek
02092	Singer Peak
02093	Big Sandstone Creek
02094	Little Sandstone Creek
02095	Battle Creek

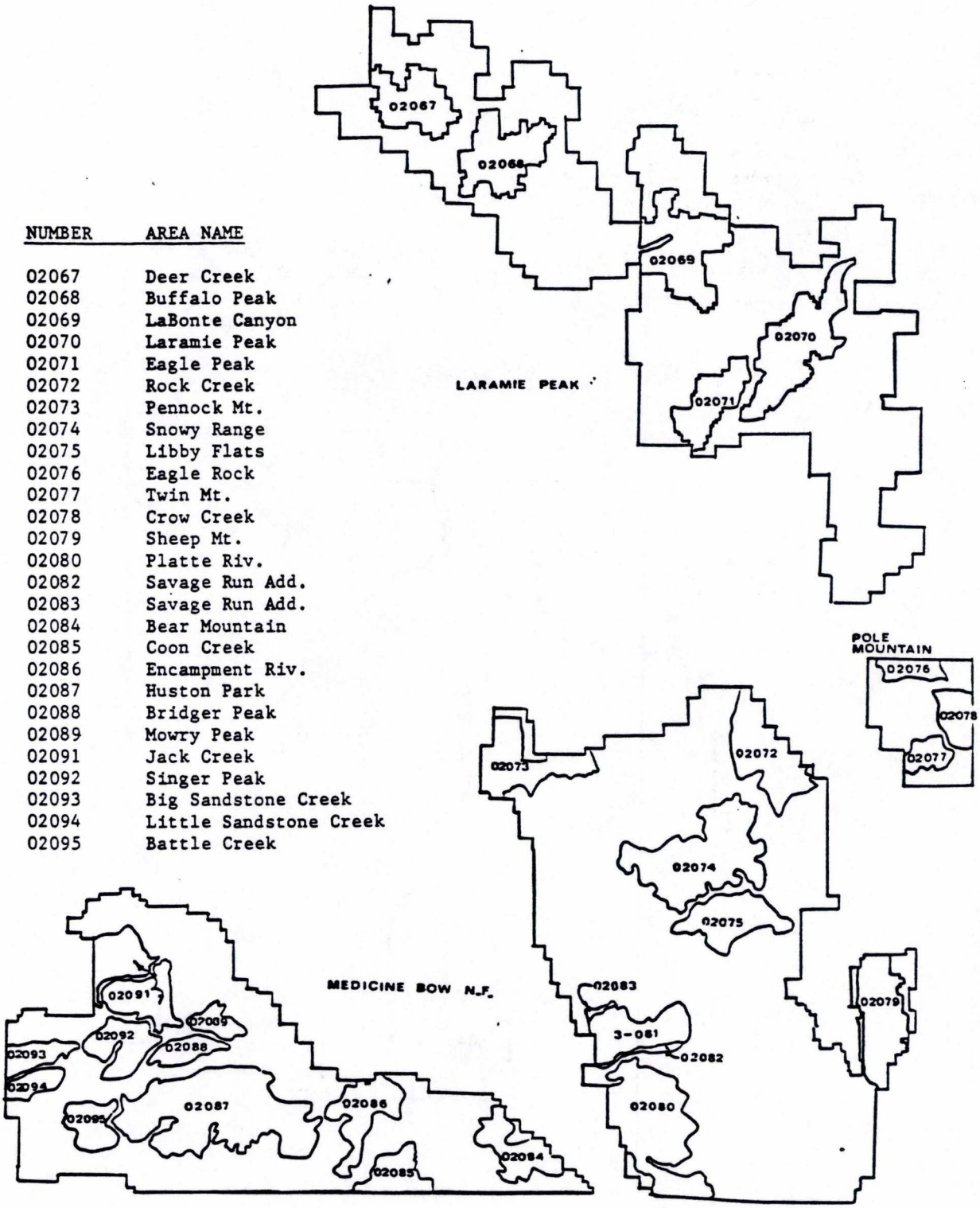


FIGURE 9.2 RARE II (Roadless) Areas identified 1976-1983. Savage Run (3-081) was already a Wilderness Area. See Table 9.2.

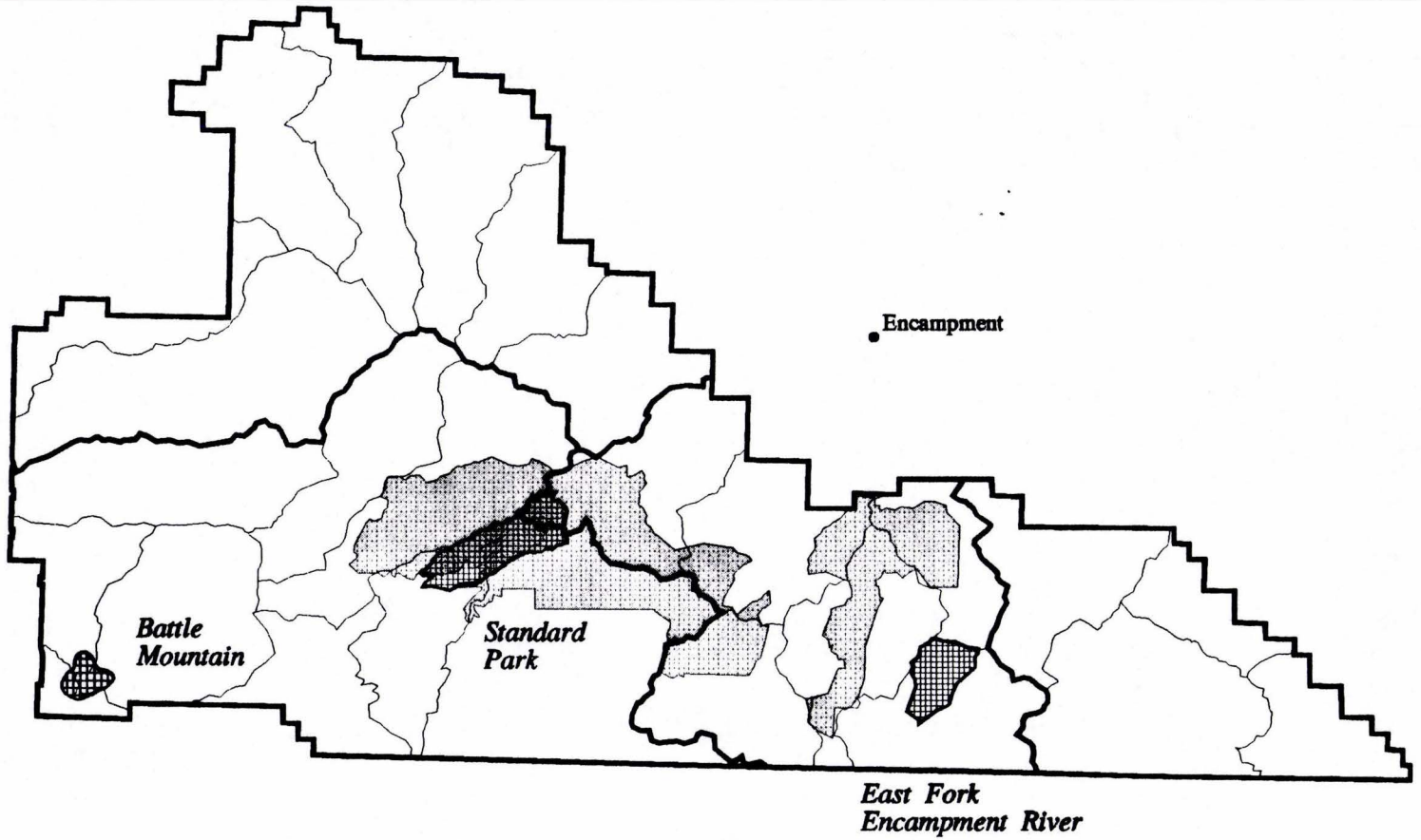
MEDICINE BOW NATIONAL FOREST — SIERRA MADRES

Potential RNA Location Map

FIGURE 9.3a

LEGEND

- Wilderness Area
- Potential Research Natural Area (RNA)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



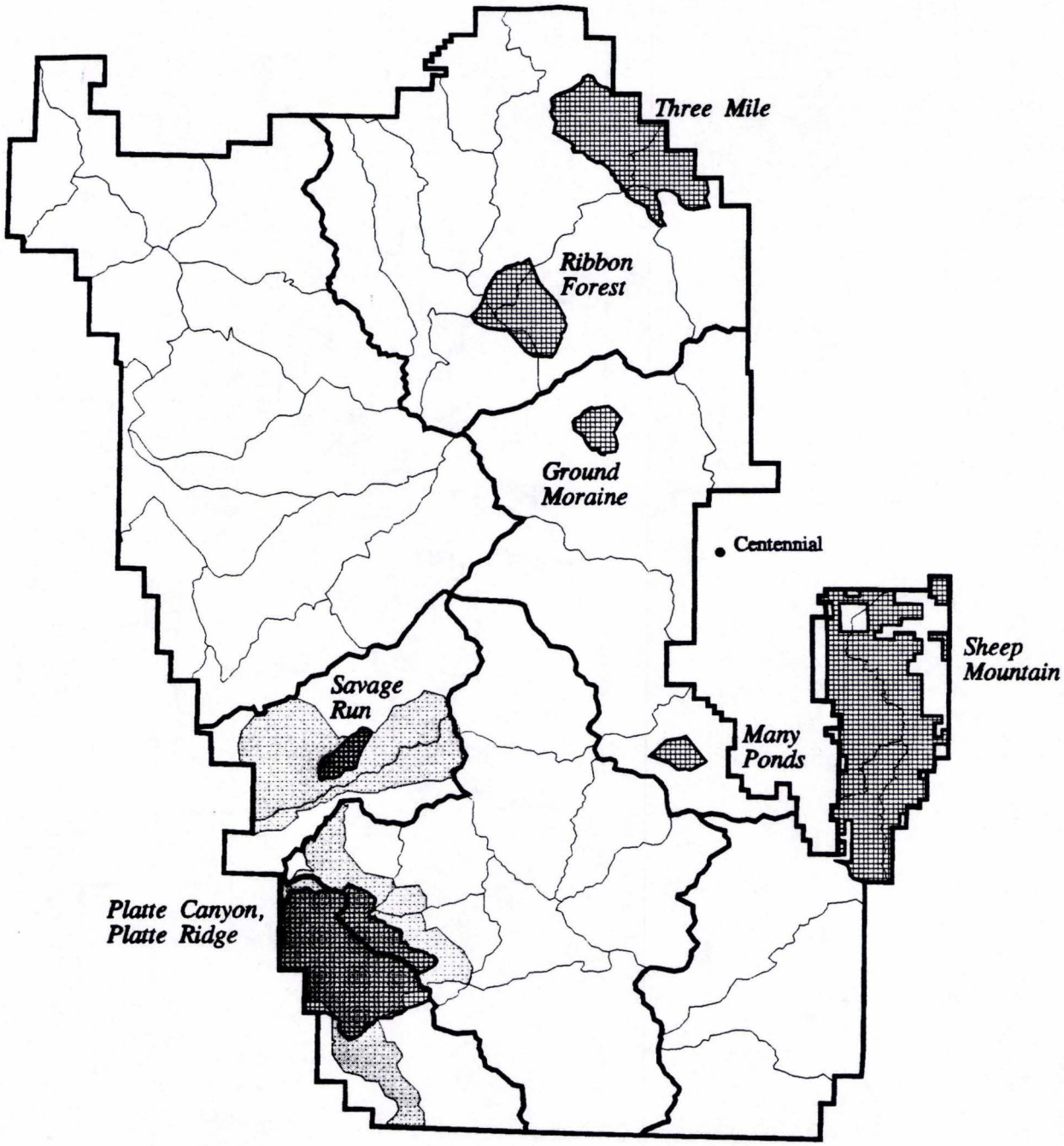
Scale 1 to 375,000

Created by CLT for JVA, 02.28.95, ms_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Potential RNA Location Map

FIGURE 9.3b



Created by CLT for JVA, 04.14.95, rna snowy.aml

LEGEND

- Wilderness Area
- Potential Research Natural Area (RNA)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

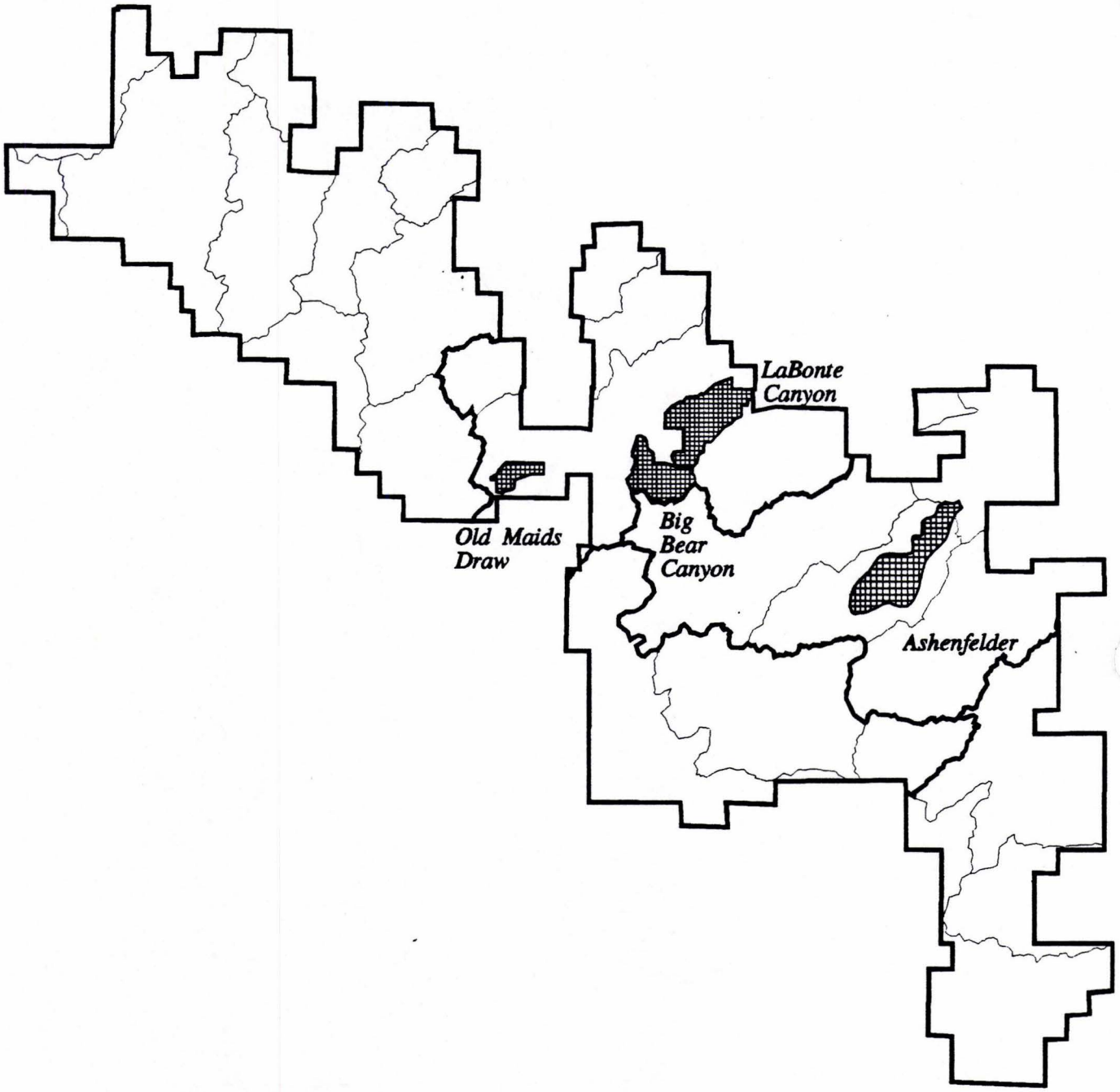
Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

LARAMIE RANGE

Potential RNA Location Map

FIGURE 9.3c



Created by CLT for JVA, 01/19/95, ma laramie.aml

LEGEND

- Wilderness Area
- Potential Research Natural Area (RNA)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

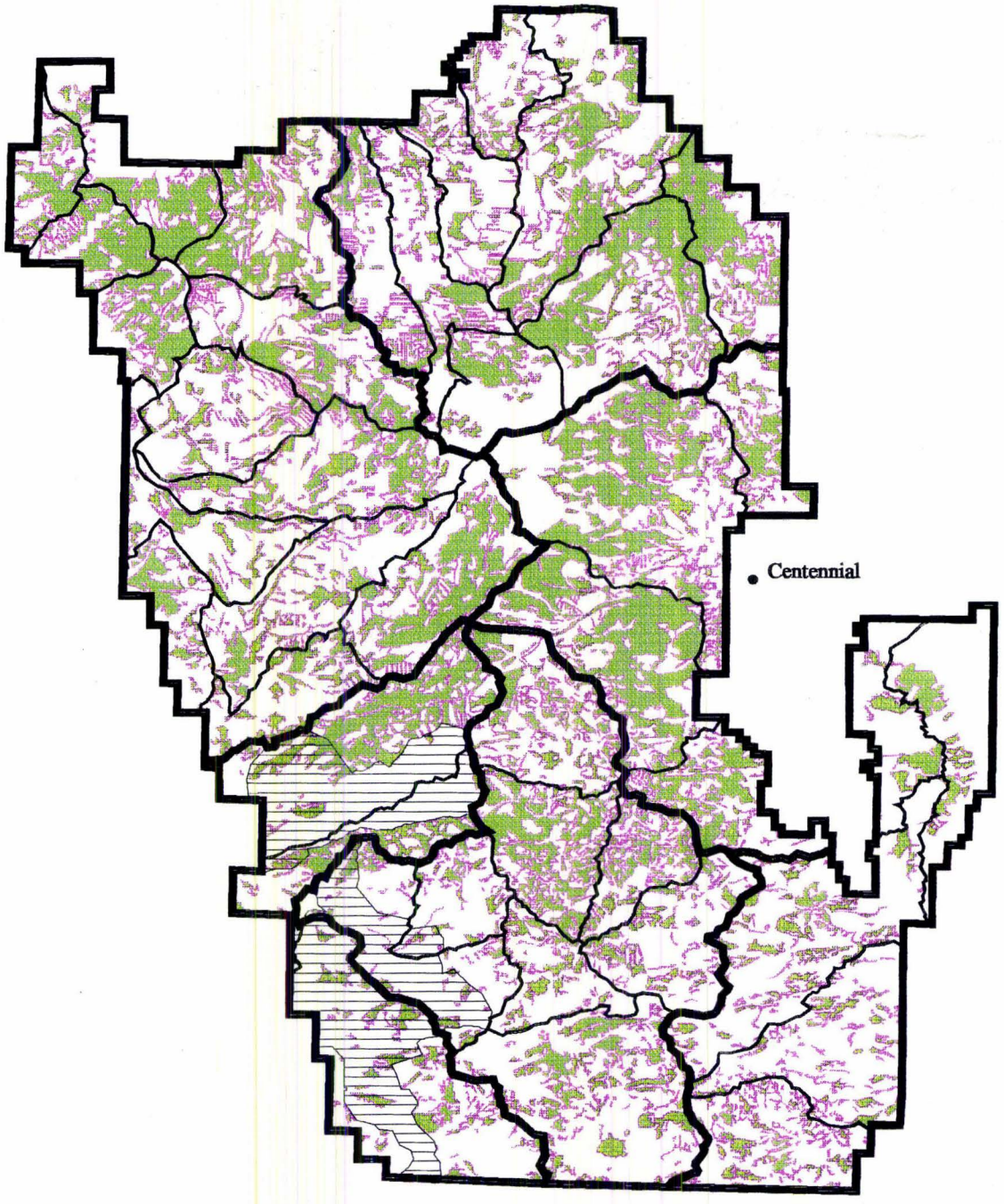
Scale 1 to 425,000

MEDICINE BOW NATIONAL FOREST

Interior Old Growth Forest

SNOWY RANGE

FIGURE 9.4a



Created by CLT for JVA, 02.27.95, int snowy.aml

LEGEND

Old Growth:
(Scorecard ge 38
or
Struct. Stage
4a,4b,4c,5 or
age le 1799)

- No Edge Effect
- 60 Meter Edge Effect
- Wilderness Area
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Interior Old Growth Forest

SIERRA MADRES

FIGURE 9.4b

LEGEND

Old Growth: (Scorecard ge 38 or Struct. Stage 4a,4b,4c,5 or age le 1799)

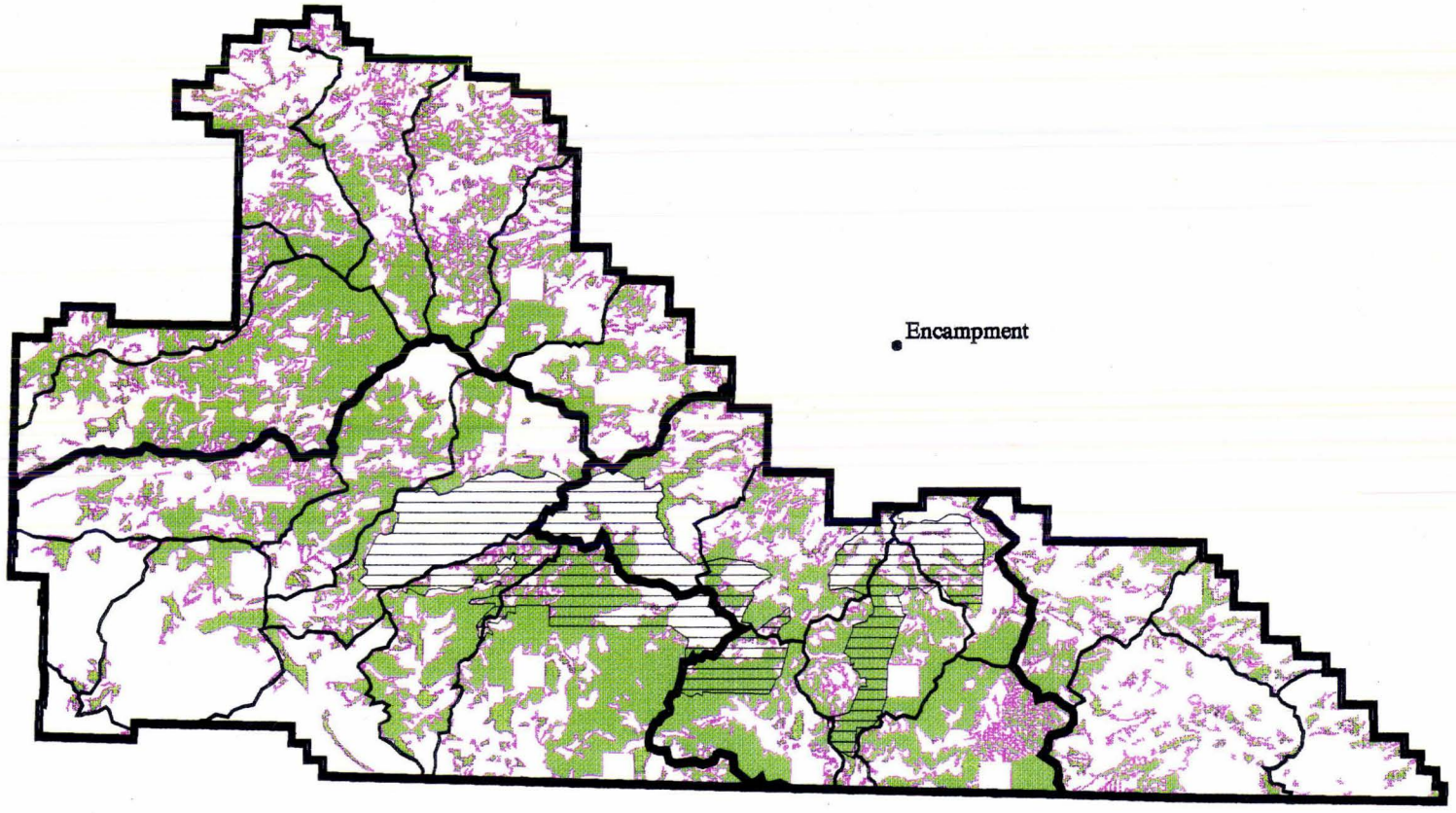
No Edge Effect

60 Meter Edge Effect

Wilderness Area

Biodiversity Unit Boundary

Biodiversity Area Boundary



Scale 1 to 375,000

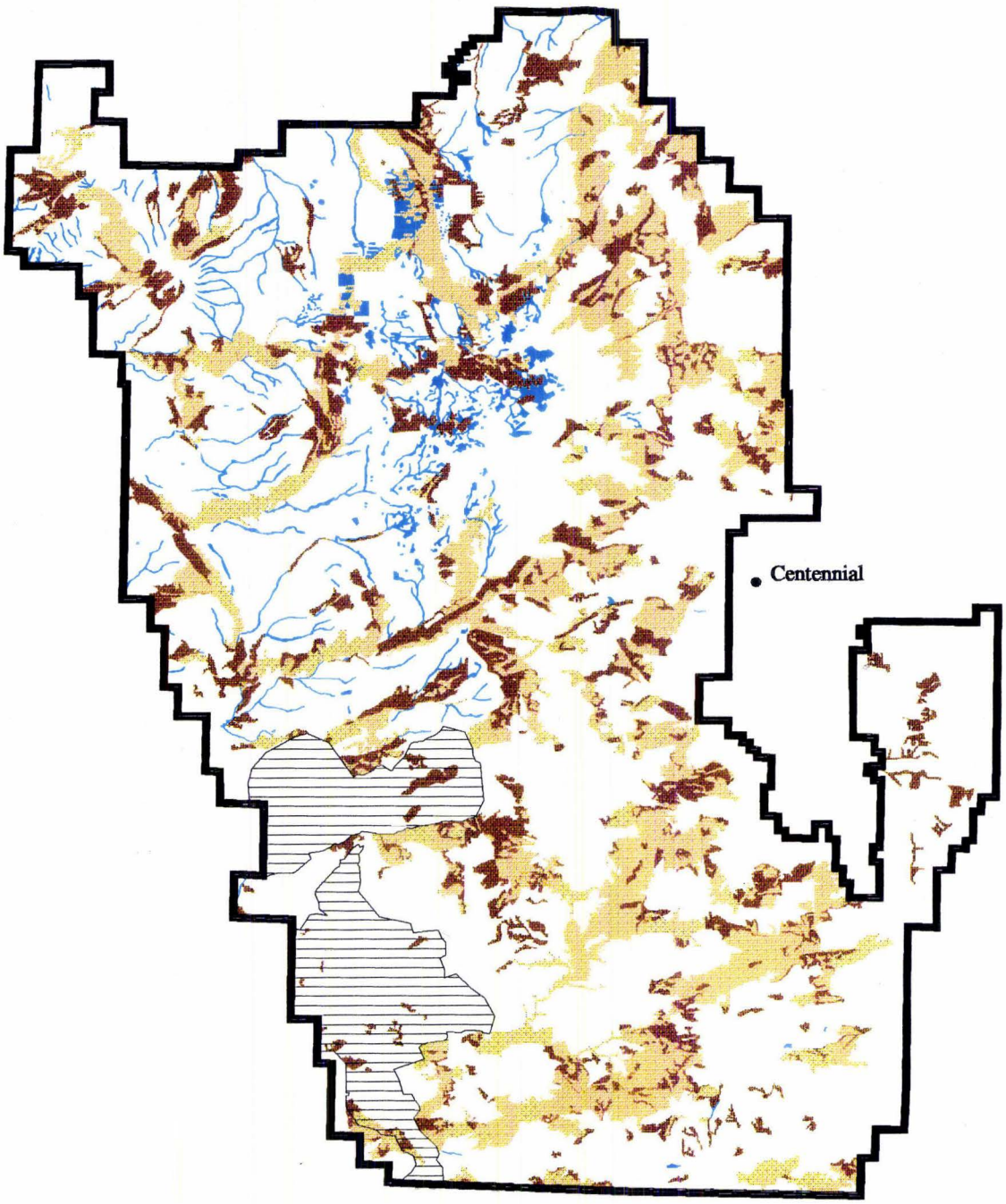
Created by CLT for JVA, 02.28.95, int_sierra.aml

MEDICINE BOW NATIONAL FOREST

SNOWY RANGE

FIGURE 9.5a

Proposed Old Growth Patch and Linkage System



Created by CLT for JVA, 01/19/95, loc snowy.aml

LEGEND

- Designated, Linkage (LD) or Designated, Patch (PD)
- Nondesignated, Linkage (LN) or Nondesignated, Patch (PN)
- Management Area 9A Not in the Patch and Linkage system.
- Wilderness

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

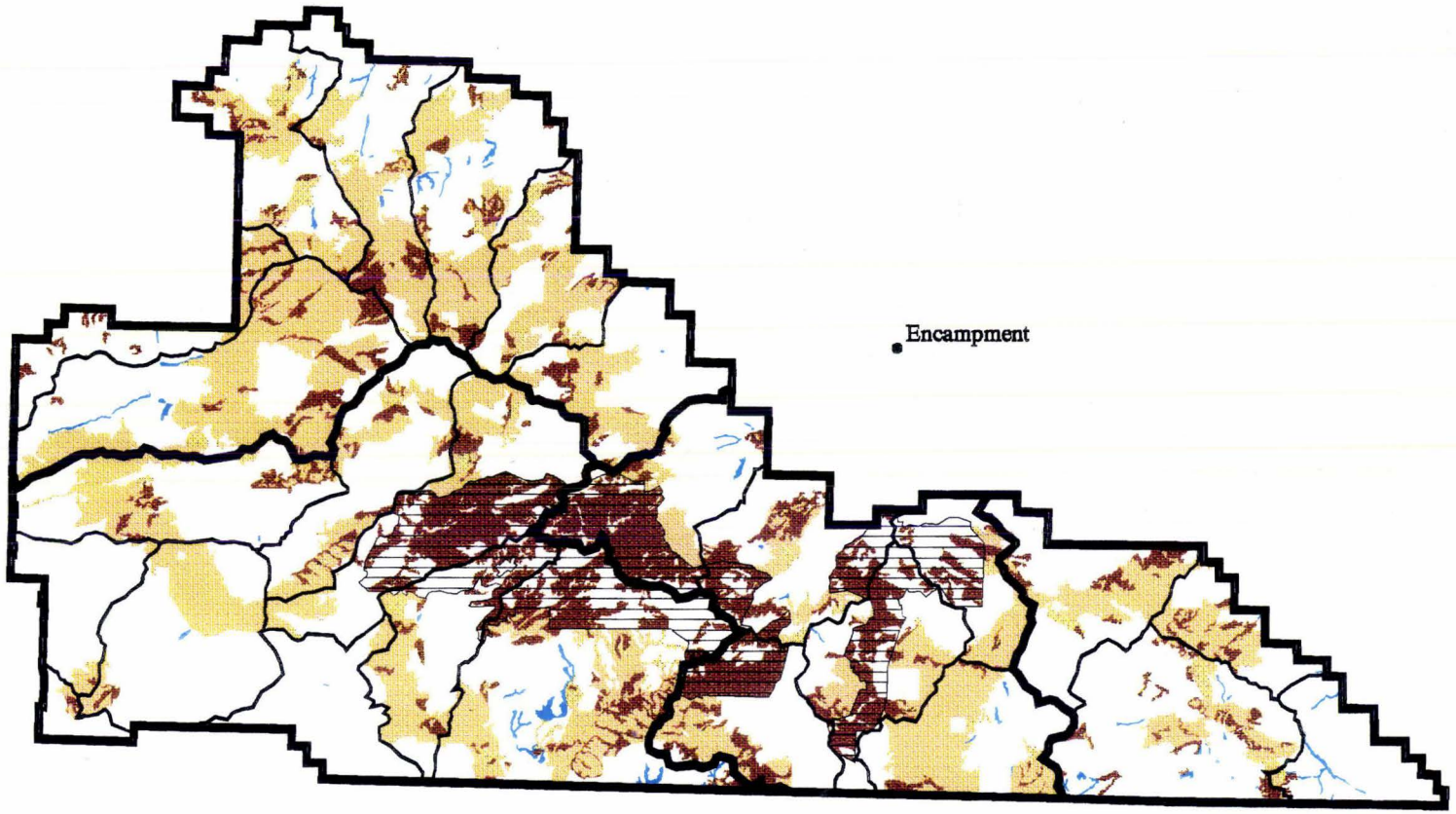
SIERRA MADRES

Proposed Old Growth Patch and Linkage System

FIGURE 9.5b

LEGEND

- Designated, Linkage (LD) or Designated, Patch (PD)
- Nondesignated, Linkage (LN) or Nondesignated, Patch (PN)
- Management Area 9A Not in the Patch and Linkage system.
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, loc_sierra.aml

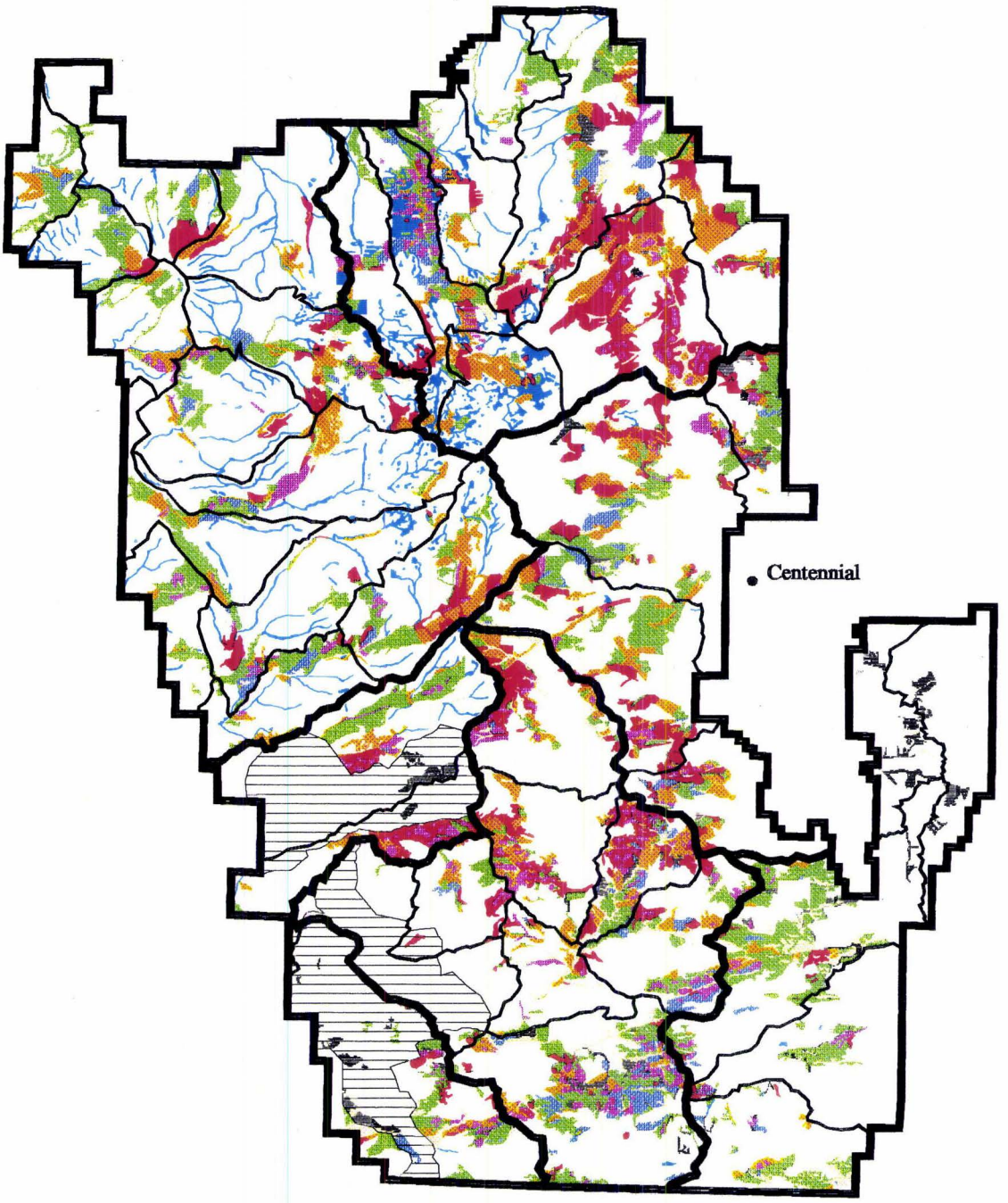
MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System

Relationship to Stand Age

SNOWY RANGE

FIGURE 9.6a



Created by CLT for JVA, 01/19/95, age snowy.aml

LEGEND

STAND AGE:

- 195 years old and older (year of origin <= 1799)
- 145 through 194 years old (year of origin 1800-1849)
- 84 through 144 years old (year of origin 1850-1910)
- 45 through 83 years old (year of origin 1911-1949)
- 44 years old and younger (year of origin >= 1950)
- No age data openings (not forested)
- No age data Forested
- Management Area 9A NOT in the Patch and Linkage system
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System
Relationship to Stand Age

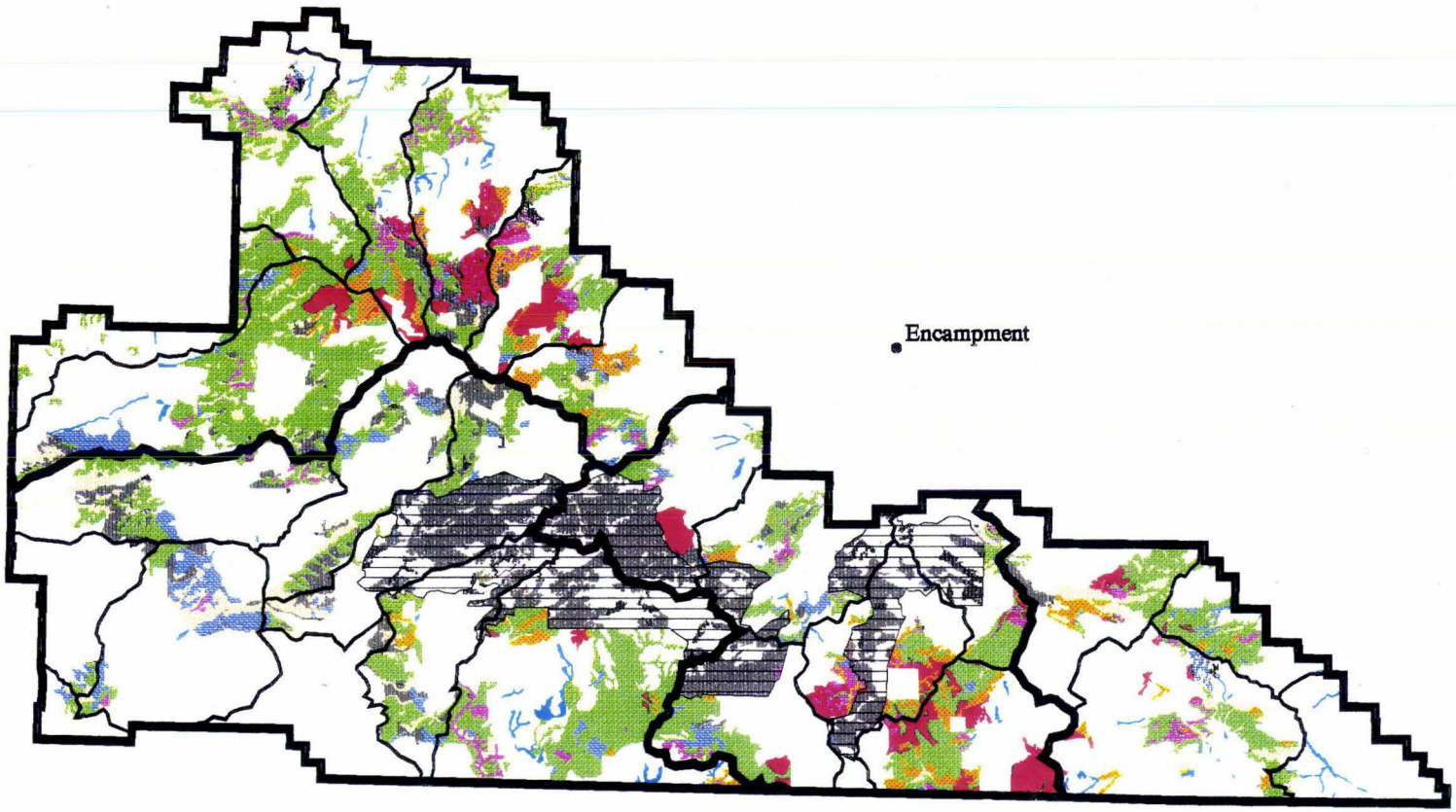
SIERRA MADRES

FIGURE 9.6b

LEGEND

STAND AGE:

- 195 years old and older (year of origin <= 1799)
- 145 through 194 yrs old (year of origin 1800-1849)
- 84 through 144 yrs old (year of origin 1850-1910)
- 45 through 83 yrs old (year of origin 1911-1949)
- 44 yrs old and younger (year of origin >= 1950)
- No age data openings (not forested)
- No age data Forested
- Management Area 9A NOT in the Patch and Linkage system
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, age_sierra.aml

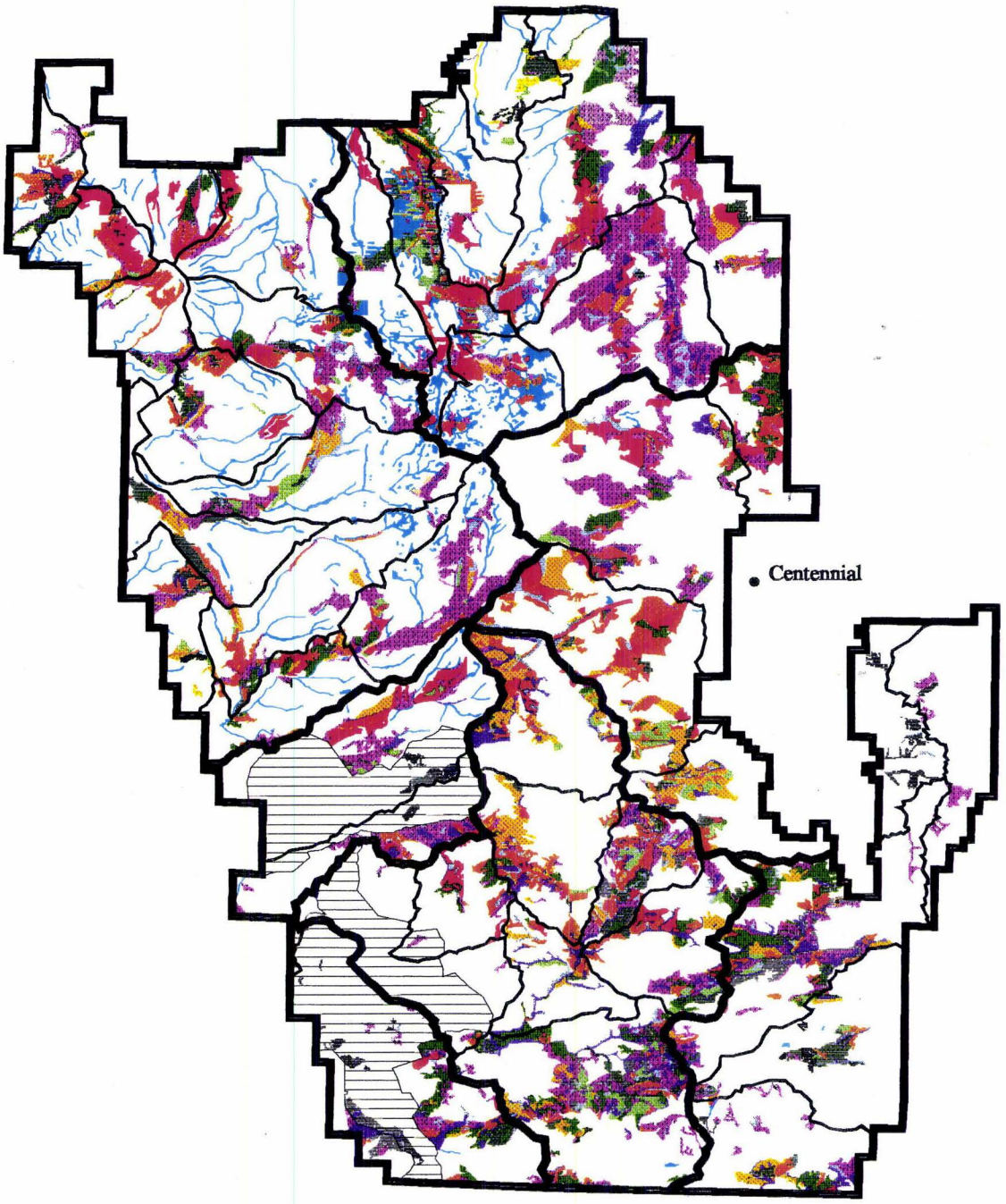
MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System

Relationship to Habitat Structural Stage

SNOWY RANGE

FIGURE 9.7a



Created by CLT for JVA, 01/19/95, has snowy.aml

LEGEND

- 1 (Grass/Forb)
- 2 (Shrub/Seedling)
- 3A (Sapling/Pole)
- 3B (Sapling/Pole)
- 3C (Sapling/Pole)
- 4A (Mature)
- 4B (Mature)
- 4C (Mature)
- 5 (Old Growth)
- Forested, no data
- Openings, no data
- Management Area 9A, not in system
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

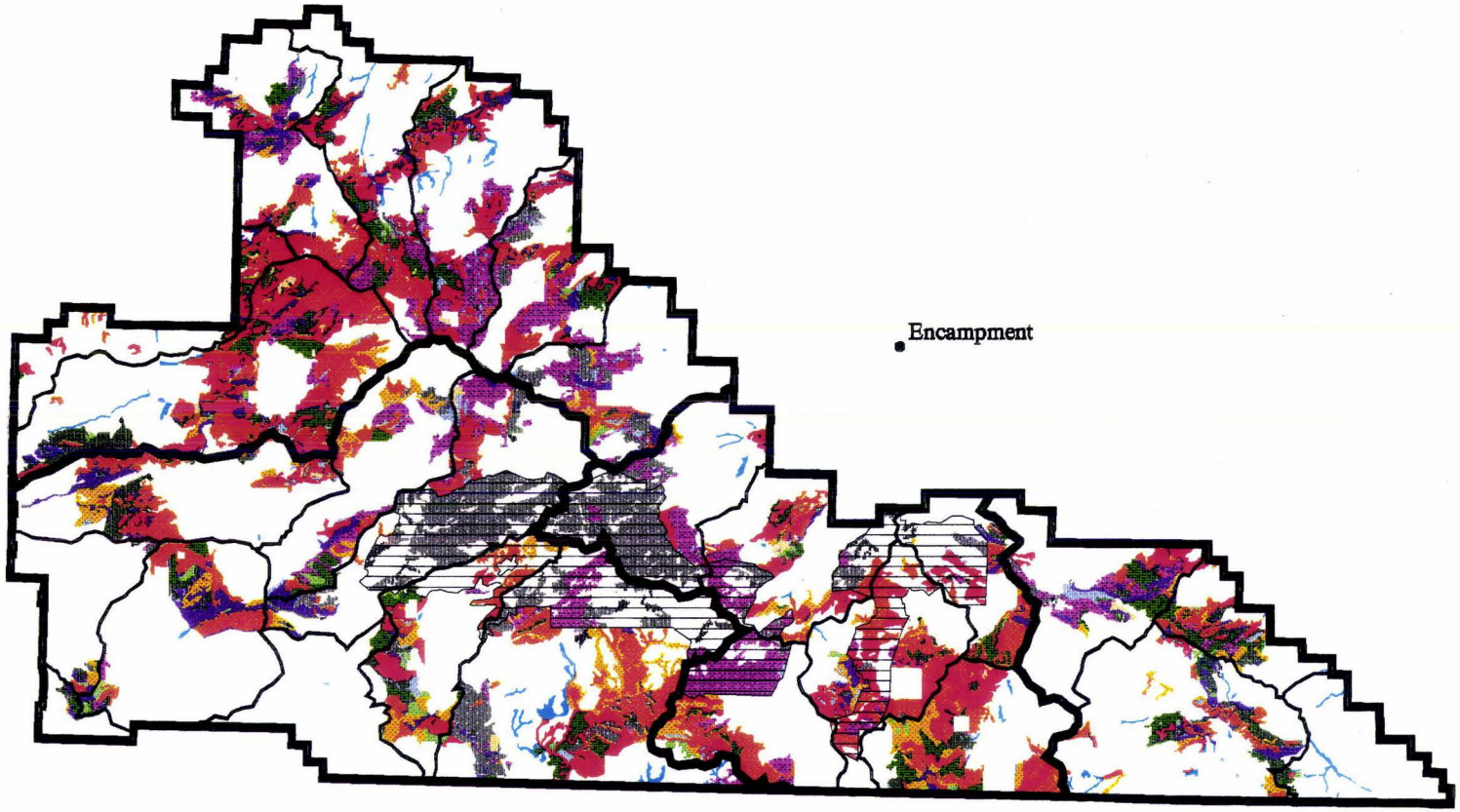
MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System

Relationship to Habitat Structural Stage

SIERRA MADRES

FIGURE 9.7b



LEGEND

Habitat Structural Stages:

GRASS/FORB
1

SHRUB/SEEDLING
2

SAPLING/POLE
3A

3B

3C

MATURE
4A

4B

4C

OLD GROWTH
5

No Data:

Forested, no data

Openings, no data

Management Area 9A, not in system

Wilderness

Biodiversity Unit Boundary

Biodiversity Area Boundary

Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, hss_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Proposed Old Growth Patch and Linkage System

Relationship to Old Growth Scorecard

FIGURE 9.8

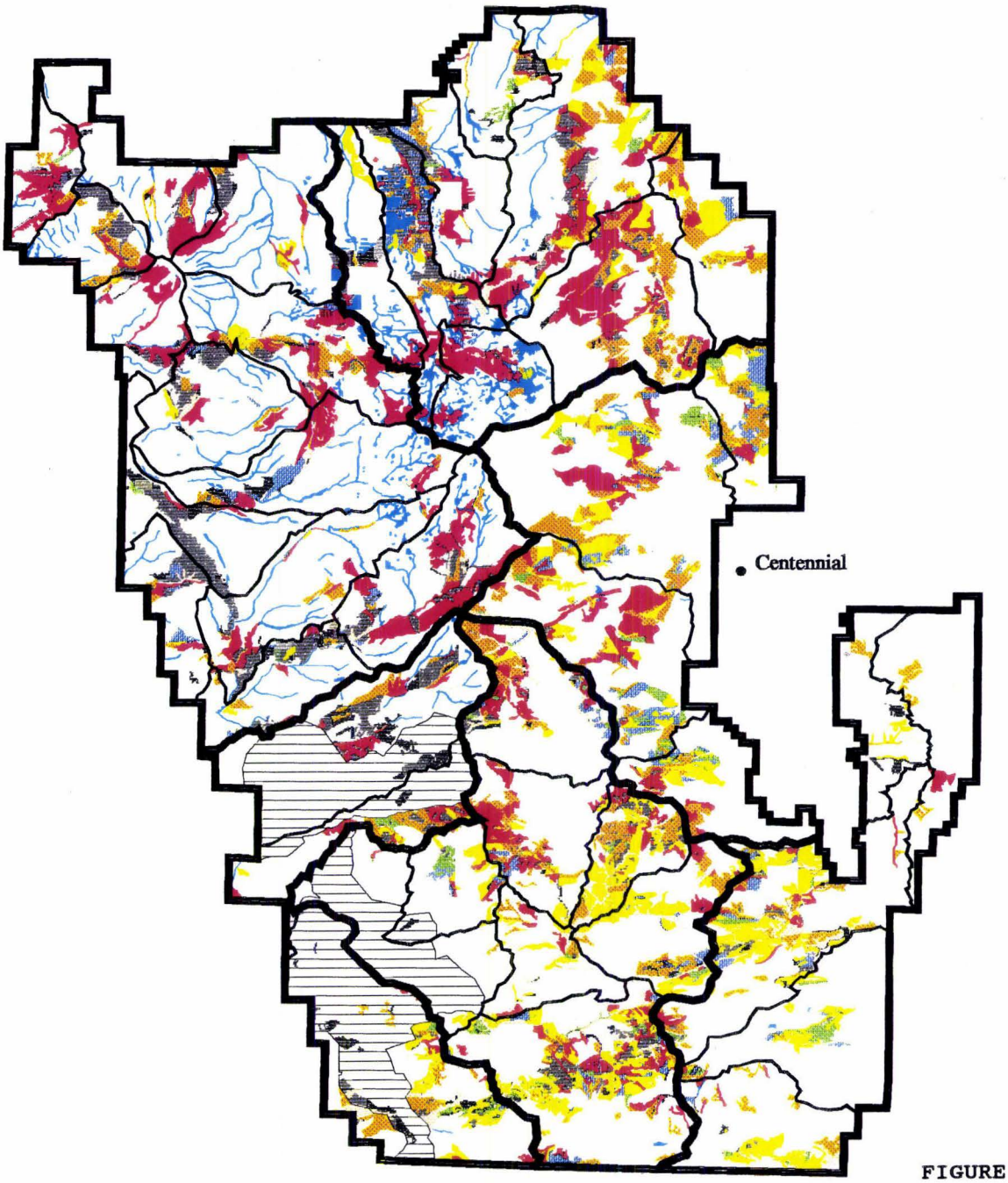


FIGURE 9.8a

Created by CLT for JVA, 01/19/95, sc snowy.aml

LEGEND

Scorecard Value:
- <= 25
- 25 - 29
- 30 - 37
- 38 - 45
- >= 46

- No data, openings (non forested)
- No data, forested (or value of 0)
- Management area 9A, not in system

- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System

Relationship to Old Growth Scorecard

SIERRA MADRES

FIGURE 9.8b

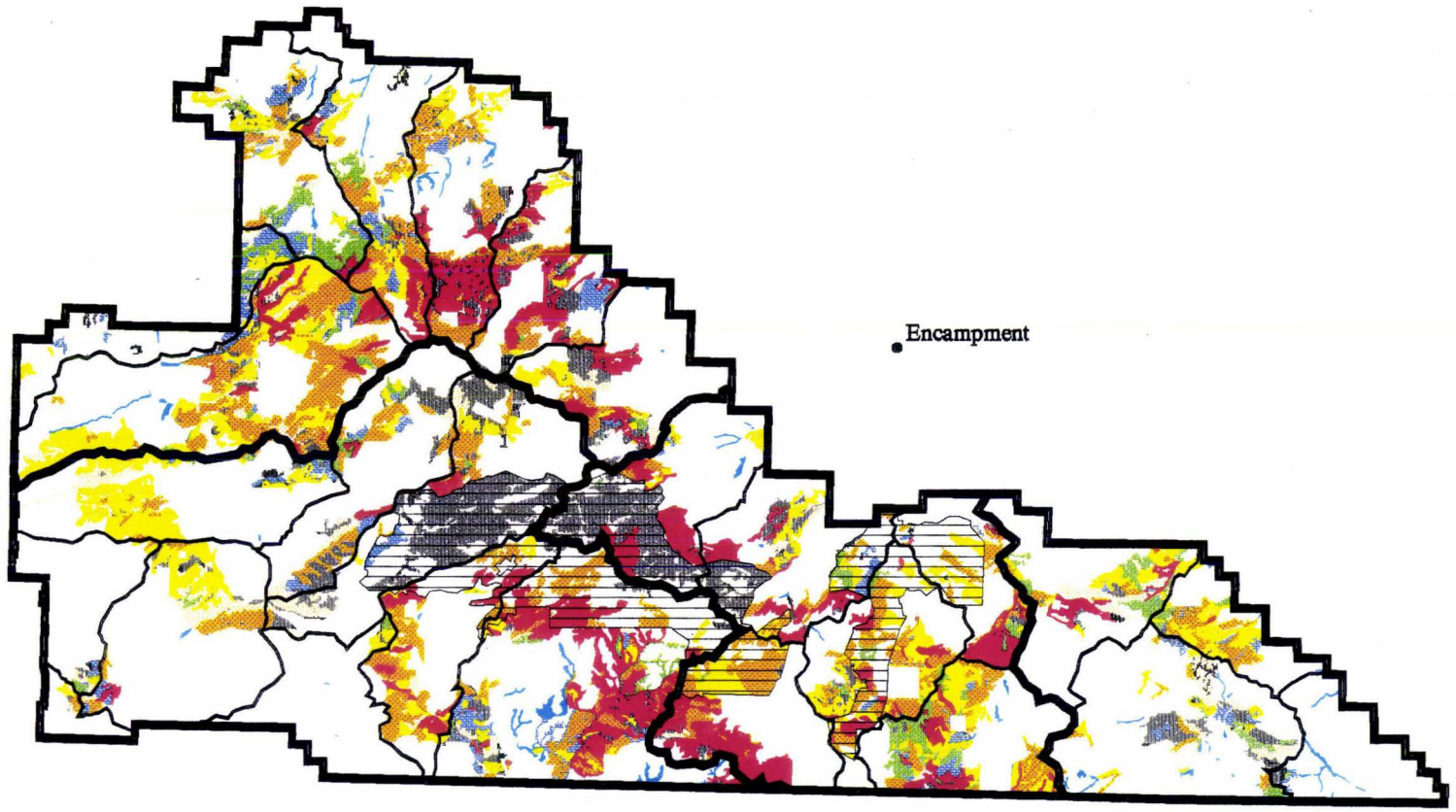
LEGEND

Old Growth Scorecard Value:

- <= 25
- 25 - 29
- 30 - 37
- 38 - 45
- >= 46

Other:

- No data, openings (non forested)
- No data, forested (or value of 0)
- Management area 9A, not in system
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, sc_sierra.aml

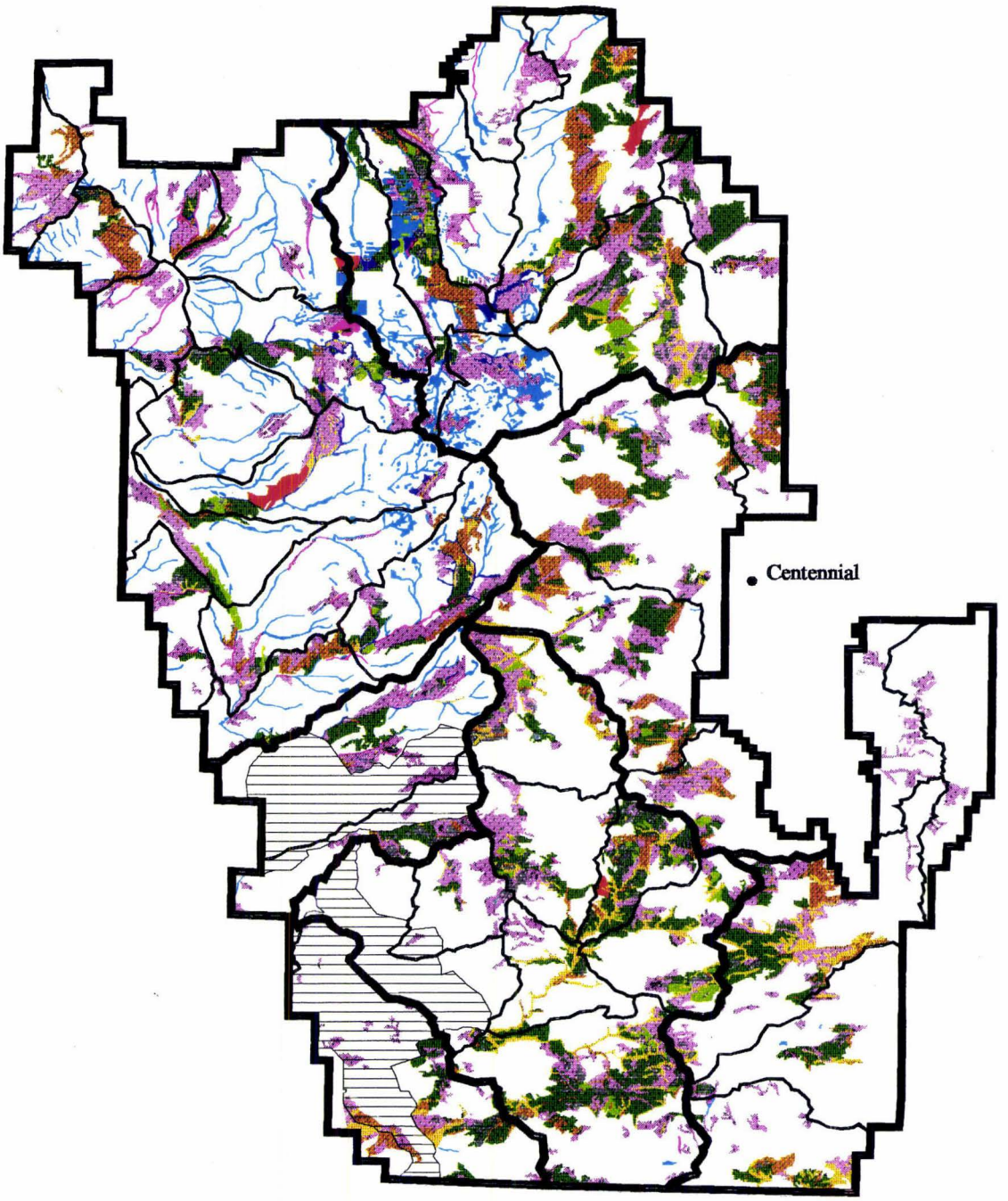
MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System

Relationship to Timber Suitability

SNOWY RANGE

FIGURE 9.9a



Created by CLT for JVA, 01/19/95, suit_snowy.aml

LEGEND

- Designated (LD or PD) in management area 9A
- Designated (LD or PD) not in mangement area 9A
- Nondesignated (LN or PN) Suitable, uncut since 1950
- Nondesignated (LN or PN) Suitable, Partial Cut
- Nondesignated (LN or PN) Suitable, Clearcut
- Nondesignated (LN or PN) Suitable, Fire/Blowdown
- Nondesignated (LN or PN) Unsuitable, with trees
- Nondesignated (LN or PN) Unsuitable, no trees
- Nondesignated (LN or PN) Unsuitable Management Area 9A
- All other mapped 9A Not in Patch/Linkage System
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

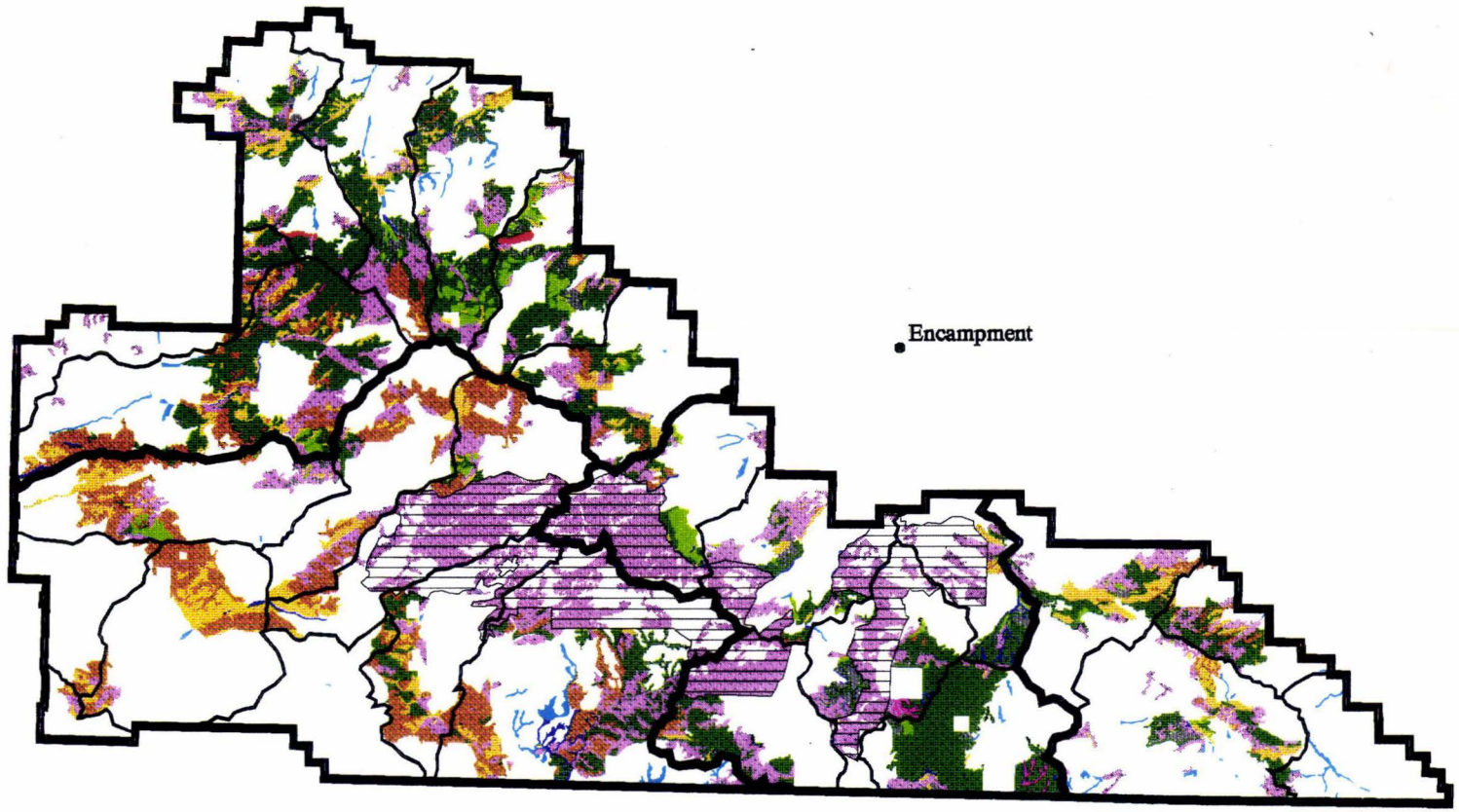
Proposed Old Growth Patch and Linkage System
Relationship to Timber Suitability

SIERRA MADRES

FIGURE 9.9b

LEGEND

- Designated (LD or PD) in management area 9A
- Designated (LD or PD) not in mangement area 9A
- Nondesignated (LN or PN) Suitable, uncut since 1950
- Nondesignated (LN or PN) Suitable, Partial Cut
- Nondesignated (LN or PN) Suitable, Clearcut
- Nondesignated (LN or PN) Suitable, Fire/Blowdown
- Nondesignated (LN or PN) Unsuitable, with trees
- Nondesignated (LN or PN) Unsuitable, no trees
- Nondesignated (LN or PN) Unsuitable Management Area 9A
- All other mapped 9A Not in Patch/Linkage System
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, suit_sierra.aml

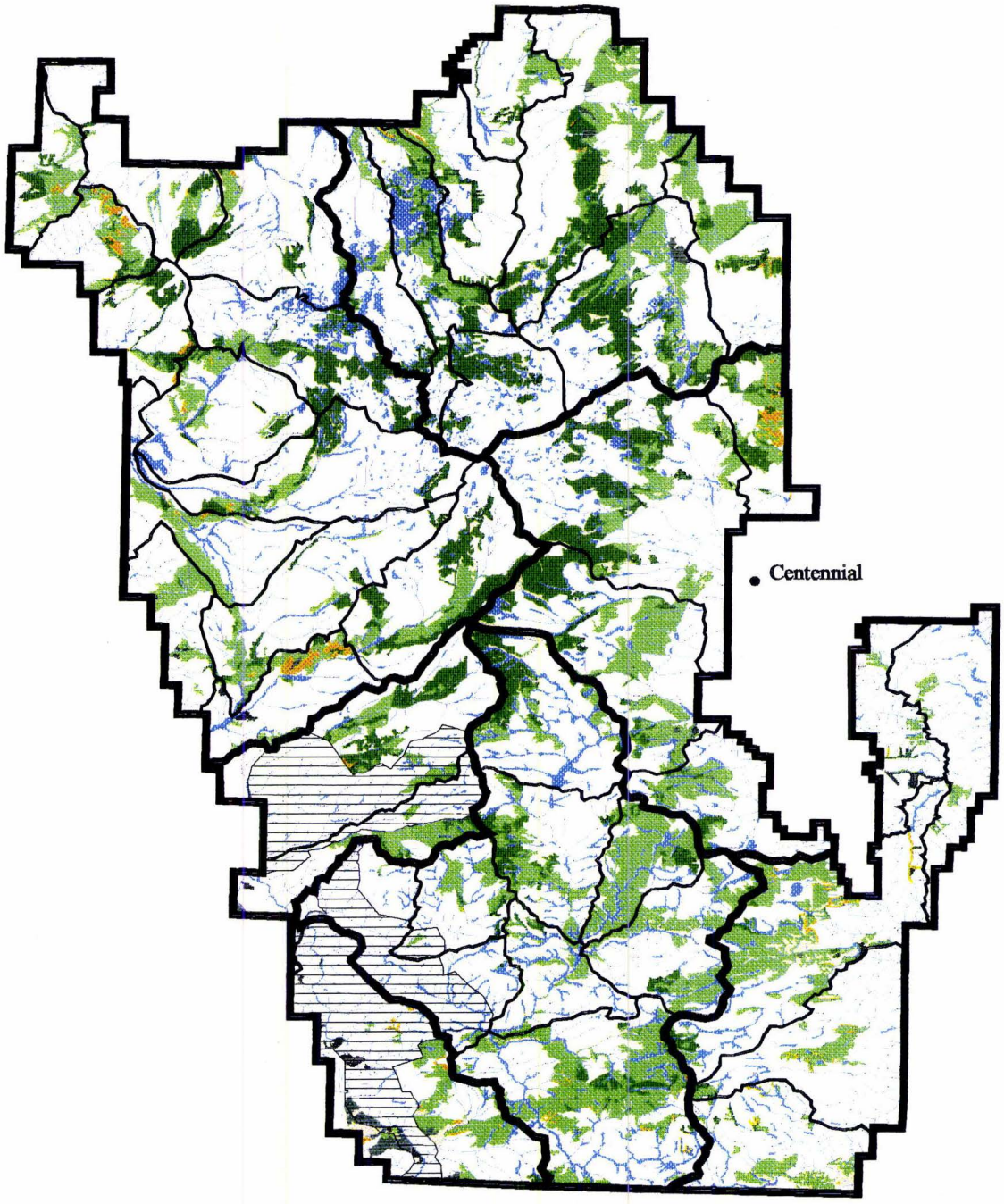
MEDICINE BOW NATIONAL FOREST

Proposed Old Growth Patch and Linkage System

Relationship to Cover Type

SNOWY RANGE

FIGURE 9.10a



Created by CLT for JVA, 01/19/95, cov snowy.aml

LEGEND

- Lodgepole Pine
- Spruce-fir
- Other Conifer
- Aspen
- Non-forested (shrub/forb/grass)
- Riparian (both in and out of the system)
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

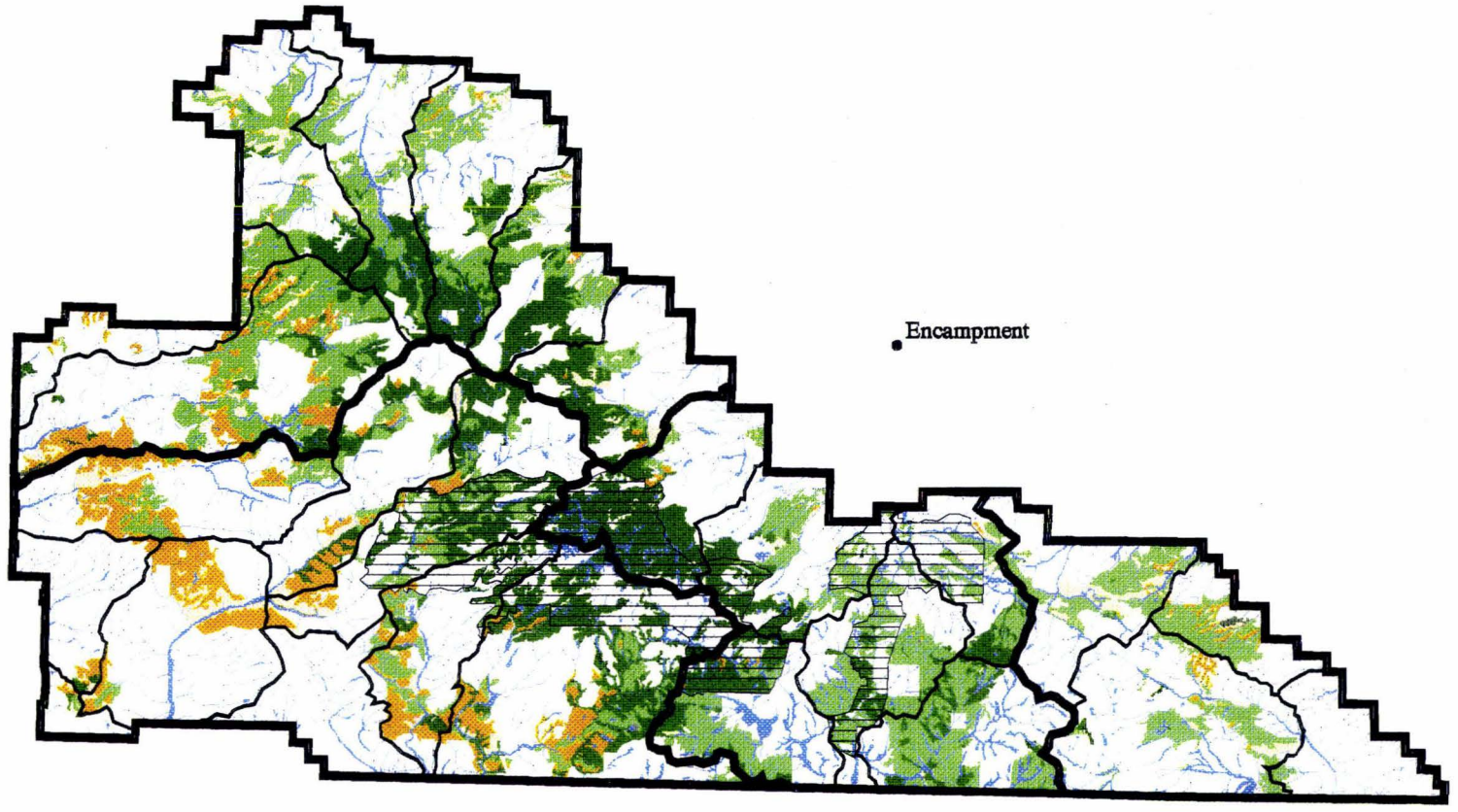
Proposed Old Growth Patch and Linkage System
Relationship to Cover Type

SIERRA MADRES

FIGURE 9.10b

LEGEND

- Lodgepole Pine
- Spruce-fir
- Other Conifer
- Aspen
- Non-forested (shrub/forb/grass)
- Riparian (both in and out of the system)
- Wilderness
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



Scale 1 to 375,000

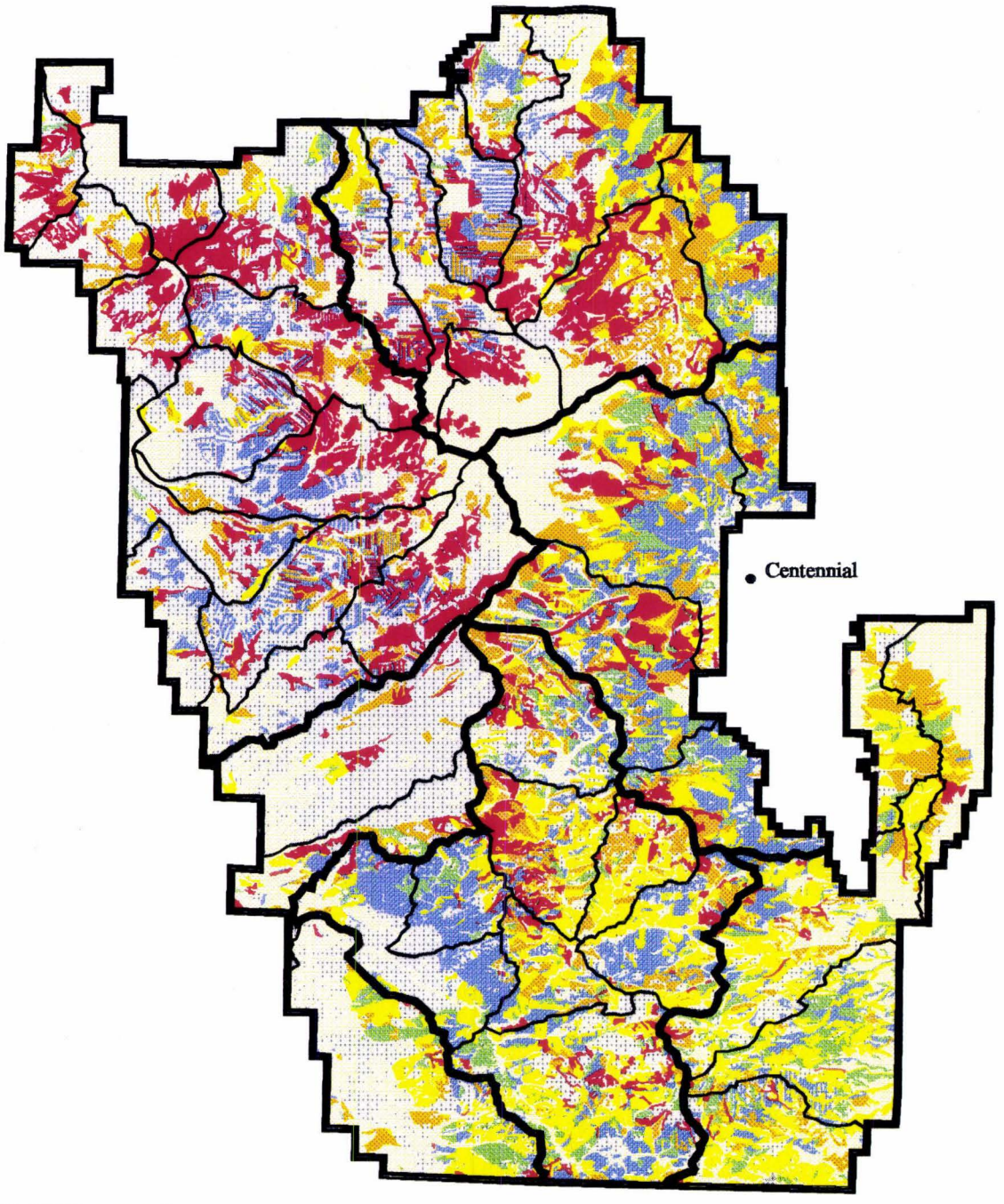
Created by CLT for JVA, 01/19/95, cov_sierra.aml

MEDICINE BOW NATIONAL FOREST

Old Growth Scorecard Map

SNOWY RANGE

FIGURE 9.11



Created by CLT for JVA, 01/17/95, sc snowy.aml

LEGEND

- 01 - 24
- 25 - 29
- 30 - 37
- 38 - 45
- 46 and greater
- Forested, no data or score of 0
- Other, no data (openings, State, Private, water)
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

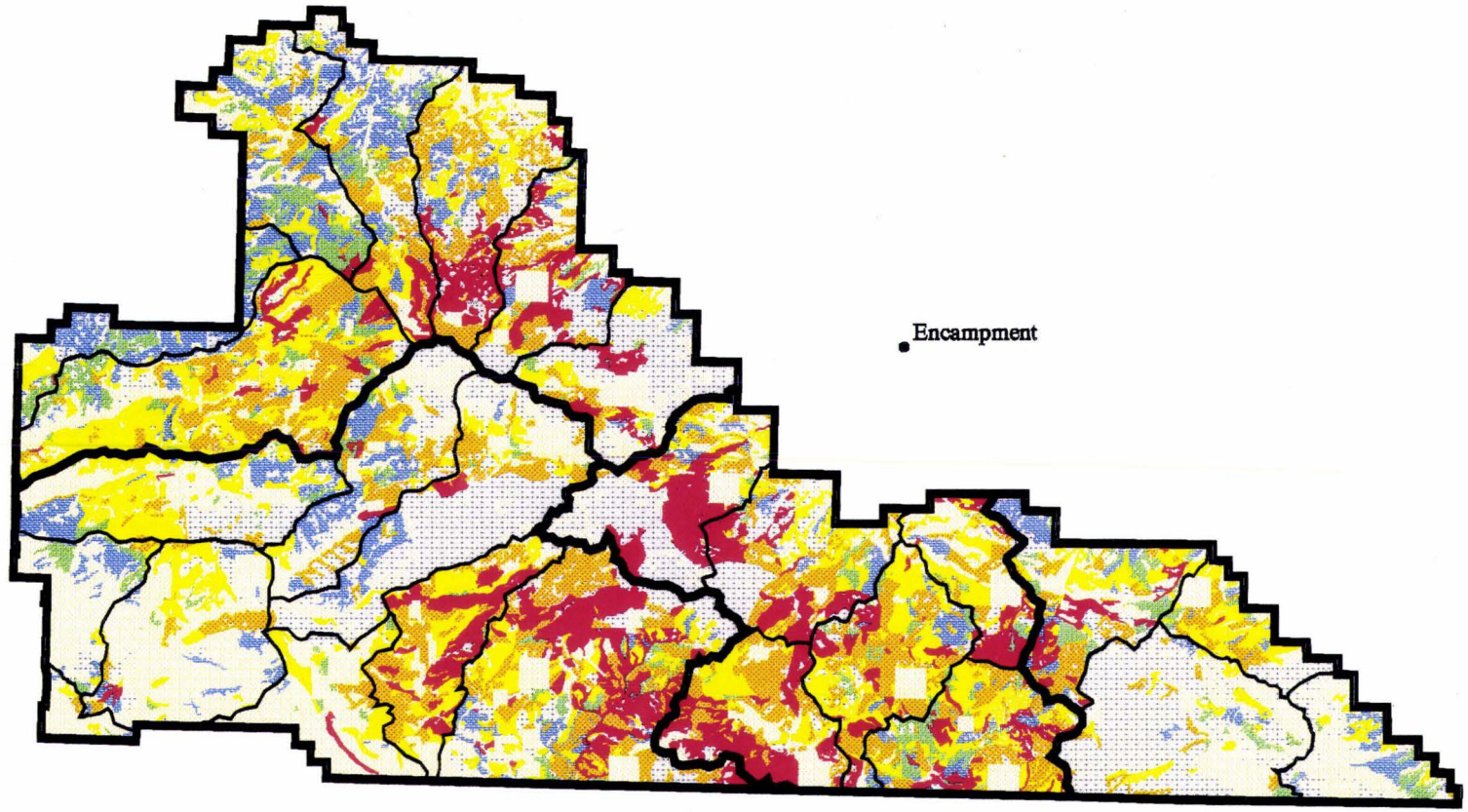
Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST

Old Growth Scorecard Map

SIERRA MADRE

FIGURE 9.11



Created by CLT for JVA, 01/17/95, sc_sierra.aml

CHAPTER 10

CONCERNS AND CONSIDERATIONS

INTRODUCTION

Identification of specific concerns regarding biological diversity and ecological integrity in this chapter are based on analyses done by MBNF staff specialists. These are presented as considerations for monitoring, for areas which need additional study because of data gaps, for Forest Plan Revision considerations and for management considerations at the project level.

Many of the concerns regarding biological diversity identified in both the Five-Year Review (MBNF 1990) and the Forest Plan Revision Scoping Analysis (MBNF 1993) actually targeted ecological integrity - the maintenence of native species and ecosystems rather than the broader concept of biological diversity. Most concerns involved late successional and old growth forests and associated species; mid to late seral riparian conditions and associated species; stream channel conditions, and water quality.

GENERAL CONCERNS AND CONSIDERATIONS:

Consider taking steps to improve institutional memory so that past work is more widely known among resource specialists, planners, and managers and shared with interested publics. Some ways to do this are: 1) establish libraries of resource material in the Supervisor's office and on Districts and 2) put this information on a bibliographic database such as Pro-Cite so that information located in both District libraries and the Supervisor's Office can be located and shared.

Compile past outputs for livestock grazing and timber harvest with presentation by watershed or some other approprate unit that is smaller than a forest-wide total. This will provide a context for past and future ecosystem management.

Present all monitoring information in a consistent, summarized, understandable way. Part of the difficulty in assessing impacts of resource use on biological diversity and ecological integrity is lack of a consistent data framework to enable comparison of different kinds of data using compatible temporal and spatial scales.

Consider adopting the pattern of landscape organization using USGS watersheds into BDUs and BDAs as presented in this report as a basis for data organization and monitoring.

Consider more adaptive management. There has been too much lag in changing management practices or amending the Forest Plan in the past to correct problems which have been identified or when new information is available.

Consider coordinating with adjacent Colorado forests for landscape patch and connectivity characteristics and habitat management for wide-ranging species and neotropical migratory birds.

Consider initiating assessment and monitoring of aquatic ecosystem health for both physical and biological characteristics. This would entail establishing permanent baseline monitoring stations.

Consider additional description of biological diversity and ecological integrity characteristics of the MBNF in the landscape system formed by wilderness areas, research natural areas, special interest areas, roadless areas, and the old growth patch and linkage system. This description should be at the scale of the different areas in the context of watersheds and include landscape pattern, vegetation, landform characteristics, and species of interest. The ecological evaluations and environmental assessments for the proposed and potential research natural areas (Jankovsky-Jones, 1995) provide some of this kind of information, but additional field work is needed for wilderness areas, roadless areas, special interest areas, and old growth areas for future management.

Develop monitoring programs for populations of large predators (black bear, mountain lion, bobcat) in cooperation with the Wyoming Game and Fish Department.

Develop survey and monitoring programs for neotropical migratory birds as recommened by draft Regional guidelines (Roth 1994). Survey and monitoring of NTMB in high-elevation spruce-fir and spruce forests might be a priority.

Consider purpose and use of management indicator species (MIS) during Forest Plan Revision. Most present MIS are not adequately monitored and do not provide useful information for managing ecosystems. Consider using groups of MIS for monitoring specific ecosystems (i.e. monitor fewer ecosystems in more meaningful ways).

Consider monitoring of effects of snowmobiling on plants and animals.

CONCERNS AND CONSIDERATIONS BY ECOSYSTEM SCALE

TERRESTRIAL ECOSYSTEMS

Coarse Filter

1. Landscape patterns of forest age fragmentation caused by dispersion of younger structural stages and age classes within old, formerly continuous-canopy forests

2. Patch size, species composition, distribution, and connectivity of old growth and late successional forest

3. Effective interior area of old growth forest and effect of edge

Fine Filter

1. Effects of forest age fragmentation on native flora and fauna, especially TECS species and neotropical migratory birds.

2. Effects of roads, hunting, livestock grazing, recreation, and other widespread human activities on populations of native plants and animals

AQUATIC AND RIPARIAN ECOSYSTEMS

Coarse Filter

1. Restoration of historic structure and function to tie-driven stream systems

2. Riparian area condition, especially the interaction of beavers with riparian conditions in the Laramie Mountains and southwestern Sierra Madre Mountains.

Fine Filter

1. Population and habitat concerns for amphibians

2. Maintenence of Colorado River cutthroat trout habitat and populations.

CONCERNS AND CONSIDERATIONS BY TOPIC

Old Growth

Consider discontinuing timber harvest above 10,000 feet. Further analysis of past cumulative effects is needed, as well as evaluation of future harvests on old-forest resources using computer modeling tools such as Snap II and r.le (Baker and Cai 1992).

Old individuals of all species could be conserved in all mountain ranges to for conservation of this resource and the information these trees can provide for historical ecological and climate analyses.

To achieve sustainable old growth forests, remaining old forest and old growth must be maintained and supplemented by carefully planning areas where trees 100-150 years old will be allowed to reach old forest stages (200-400 or more years of forest continuity). Landscape-scale planning is needed to produce future old forest and future old growth with adequate interior habitat and connectivity. Old forest and old growth areas should remain on the landscape for long periods of time, and not be subjected to constant respositioning as a function of demands by other resource uses. Currently the amount of old forest (older than 200 years) is low and interior habitat areas are small due to fragmentation from roads and clearcutting. There is more old growth habitat than old forest habitat, but there are few patches of either with large interior areas.

The Old Growth Patch and Linkage System codified in Chapter 9 was initiated on the Brush Creek District and is being implemented by both the Brush Creek-Hayden District and the Laramie District. While it has not been formally adopted by the MBNF as forest policy by means of a Forest Plan Amendment, the implementation of this concept is not precluded by existing Forest Plan minumum old growth requirements.

It is expected that the Old Growth Patch and Linkage System as presented in this report will be modified, however, a lot of analysis of possible sites in relationship to topographic and pattern constraints and species habitat needs has already been done. The present configuration should represent a reasonable plan for the Medicine Bow Mountains, which have had the most analysis done at the District level.

Some management strategies which can be considered for restoration and sustainability of old forest and old growth over the next 50 to 100 years are:

Consider identification of suitable patches of forest originating 1850-1909 as potential areas for development of old forest and old growth.

Consider avoidance of remaining high-quality old growth and old forest as priority areas for timber harvest, especially where these occur as large unfragmented patches.

Consider allowing restoration of larger patch sizes of old growth/old forest over time.

Consider intense silvicultural even-aged rotational management in areas which in the aggregate, form large patches of younger forest in a matrix of continuous-canopy forest. This is an alternative to the pattern of diversifying age structure in small patches ubiquitously in all areas in the suitable timber base.

Consider aggregating cutting units to minimize roads and form larger patches of younger forest within watersheds, rather than ubiquitous dispersal of young age classes.

Consider already-fragmented areas of trees which are 100-150 years old in roaded areas as primary sites for wood fiber production. Lodgepole pine forests below 9500 feet are more easily renewable than late-seral mixed species forest or spruce forest at higher elevations.

Consider where areas of intensive rotational management (80-120 years) are most appropriate and where longer rotations (200 or more years), uneven age management, or other techniques are best. Design timber harvest areas on a landscape scale concurrently with the design of old growth/old forest areas for watersheds and groups of watersheds.

Consider where areas of intensive rotational management (80-120 years) are most appropriate and where longer rotations, uneven age management or other techniques are best. Identify these areas and make a long-range plan for each watershed.

Evaluate and monitor effects of partial cutting, such as two or three-step shelterwood harvest techniques which severely alters understory microclimates and changes interior forest biological diversity characteristics of high elevation forests.

Evaluate cumulative impacts of partial cutting on interior forest habitat and forest composition, structure, processes, and functions. This could be done for both within-stand effects and watershed effects.

Evaluate dwarf mistletoe infestation by watersheds. Determine where and how much dwarf mistletoe infection is acceptable as a component of biological diversity.

Consider leaving wider zones of trees around riparian areas. Previous clearcut practices left narrow fringes of trees around riparian areas - this creates too much edge and not enough interior habitat near streams. Vary the width of leave strips.

Evaluate and monitor effects of rollerchopping on soils, shrubs, and lichens. Monitor succession and biological diversity in rollerchopped areas and compare with areas not rollerchopped. Evaluate the need for rollerchopping for different site types. Consider rollerchopping of parts of sites or alternative slash treatments.

Developing criteria integrating timber harvest sites with characteristics and remaining supply of Old Growth and Old Forest might be considered. These could include:

Placing new clearcut and partial cut sales where they will not fragment existing areas of old growth or old forest with substantial interior habitat

Developing landscape cumulative effect evaluation criteria including:

-stand age and amount of interior habitat

-relationship of a proposed timber harvest area to the watershed and nearby watersheds (i.e. how much edge and fragmentation exists, how much will the proposed site add).

-role of a specific patch in the watershed and in the ecological integrity of the area area (for example as habitat for TECS species or Neotropical Migratory birds).

-Developing criteria for harvest of non-designated old growth or old forest stands that are in linkages or buffer areas around designated old growth. These criteria would retain specified old

growth or old-forest characteristics for forested areas in the suitable timber base.

Aquatic and Riparian Ecosystems

Consider special analyses prior to any additional soil-disturbance for watersheds at risk (existing high disturbance or potential for disturbance effects).

Consider actions to correct point-source water pollution in the Sierra Madre Mountains.

Consider restoration of some watersheds identified in this report which have recieved extensive damage from hydraulic mining and tie driving (1860s-1940s). Efforts could include both the stream channel and riparian zone. A goal might be to replace even-aged stands with uneven aged stands which would provide a continuous source of large wood for stream channels in the future.

Species and genetic biological diversity

Continue surveys for populations of boreal toads and wood frogs. Special efforts chould be made to protect remaining boreal toad habitats (such as kettleholes) which have not been impacted by clearcut timber harvest since 1950.

Evaluate and monitor moose populations and impacts on riparian areas. Encourage development of moose hunting season regulations in Wyoming to enable habitat management.

Survey for populations of clustered ladyslipper (*Cypripedium facsiculatum*) - current information on populations and distribution are inadequate. Habitat for this species is affected by timber harvest.

CONCERNS AND CONSIDERATIONS BY LANDSCAPE AREA

SIERRA MADRE AND MEDICINE BOW MOUNTAINS

Terrestrial Ecosystems

Landscape measurements for many watersheds are far from the measured means of Reference Areas used to evaluate natural variation. This coarse filter approach suggests that forest age fragmentation patterns in some watersheds may be outside a range of "natural" variation (Baker 1994).

High elevation, old (200-400 years) spruce-fir and spruce forests are a limited resource occurring on both sides of the the Continental Divide in the Sierra Madre Mountains and in the northern Medicine Bow Mountains. Few areas of even a few square miles in size remain because most of this forest type has been substantially age-fragmented by clearcutting since 1950.

Closed-canopy/open understory old lodgepole pine stands (150-350 year age range) are uncommon. They occur mainly at the north end of the Medicine Bow Mountains and in the northwestern Sierra Madre Mountains. Some of these may be a topo-edaphic climax, not a seral stage to spruce-fir. Forests of this type are prime habitat for northern goshawks. This kind of forest usually contains prime, high volume timber. Inventory and long-term planning is need to conserve this resource.

Aquatic and Riparian Ecosystems

Consider special management for the known high purity populations of Colorado River Cutthroat trout in the North Fork, Little Snake River as recommended by Speas et al.(1994). The MBNF has a special responsiblity for species conservation in this regard because 40-50 percent of the populations of this species are on the MBNF.

SHERMAN MOUNTAINS AND LARAMIE MOUNTAINS

Terrestrial ecosystems

Consider fire history studies for the Ashenfelder Basin area to provide management information and to extract past climate and fire information before decay or fires makes these kinds of studies impossible.

Consider thinning of ponderosa pine and some lodgepole pine stands because fire suppression has contributed to high tree density. This might be considered for Pole Mountain to reduce danger of catastrophic fires and maintain aspen stands, and in some areas of the Laramie range for the same reasons.

Aquatic and Riparian Ecosystems

Consider assessment of beaver populations in the Laramie Mountains. A beaver management plan could be developed using a Limited Quota Area like the one presently used for beaver management on the Pole Mountain Unit. Cooperation of private landowners is essential in this effort.

This document cannot provide the answers to all concerns regarding biological diversity and ecological integrity. It is expected that it will be a foundation for discussion and further analysis.

LITERATURE CITED

Baker, W.L.; Cai, Y. 1992. The r.le programs for multiscale analysis of landscape structure using the GRASS Geographical Information System. Landscape Ecology 7(4): 291-302.

Baker, W.L. 1994. Landscape structure measurements for watersheds in the Medicne Bow National Forest using GIS analysis. Department of Geography and Recreation. University of Wyoming. Contract with the Mediicne Bow National Forest, Laramie, WY.

Jankovsky-Jones, M.; Jones, G.P.; Fertig, W. 1995. Ecological Evaluations for potential Research Natural Areas (Twelve separate reports). Prepared for the Medicine Bow National Forest by the Wyoming Natural Diversity Database. Laramie, WY.

MBNF. 1992. Medicine Bow National Forest Land and Resource Management Plan - Forest Plan Five Year Review. Fiscal years 1986-1990. Appendix B Report on the implemetnation of the Medicine Bow National Forest Plan. Medicine Bow National Forest, Laramie, WY.

MBNF. 1993. Forest Plan Revision Scoping Analysis. MBNF. Laramie, WY.

Roth, D. 1994. Neotropical migratory bird monitoring plan. USDA Forest Service Region 2. Draft report. Lakewood, CO.

APPENDIX 1

BIBLIOGRAPHY OF SCIENTIFIC STUDIES PERTAINING TO THE MEDICINE BOW NATIONAL FOREST

This Appendix contains a listing of citations for studies:

1. entirely within the Medicine Bow National Forest administrative boundary

2. partially within the administrative boundary

3. in which the Medicine Bow National Forest was part of a larger study

4. in northern Colorado on similar ecosystems on the Routt or Arapaho-Roosevelt National Forest (including some studies on the Fraser Experimental Forest)

About 900 published and unpublished studies are on this list, attesting to the enormous number of man-hours and the rich amount of information available on the physical and biological environments of the MBNF. More would be found if time permitted additional searching.

The amount and quality of information available for ecosystems and animal-landscape relationships on the MBNF is exceptional. Many of the pioneering studies on forest structure, forest harvest methods, alpine ecosystems, relationships of birds and small mammals to landscape characteristics, forest nutrient cycling, and physiology of high elevation plants were done on the MBNF. Numerous surveys by the Wyoming Game and Fish Department are listed.

The combination of a major land grant University, easily accessible mountain ranges, a Forest Service Research Station laboratory in Laramie, the State Game and Fish Wildlife Cooperative Units, the Water Resources Center and the existence of the University of Wyoming Science Camp (1920s-1950s) in the Medicine Bow Mountains, has left a rich legacy of information.

Many well-known scientists did Master's Theses or Doctoral Dissertations on the Medicine Bow National Forest, and then sent another generation of students to continue their work. Mooney, Billings, Bliss, Oosting, Daubenmire, Alexander, Bates, Baxter, Blake and Hawksworth are some noteworthy scientists of an earlier generation who published leading articles, from research done on the MBNF.

Research in the last decade has focused on a wide spectrum of subjects from effects of atmospheric pollution and climate change to assessing cumulative effects of change at the landscape level, to species physiology and ecology. Professors at the University of Wyoming and other academic institutions, Wyoming Game and Fish personnel, Forest Service Researchers and numerous graduate students continue studies to increase the understanding of nature and contribute to informed management of landscapes and species.

A National Atmospheric Deposition Site, and a National Dry Deposition Network Site are part of the Glacier Lakes Ecosystem Experiments Site (GLEES), located on the Snowy Range.

This appendix was assembled specifically for the MBNF Biological Diversity Specialist Report, to provide a summary of knowledge about species and landscapes. It was impossible to completely review the literature for every topic category for this report, but hopefully this bibliography will enable others to locate information and utilize what has already been learned. This bibliography is intended to facilitate better interdisciplinary communication, increase flow of information, and help bridge the gap between technical knowledge in the scientific community and informed decision-making among land managers and planners.

Each citation is listed once, under the most specific subject. Cross-referencing was not attempted, so it might be necessary to look under more than one category to locate information on a topic.

ORGANIZATION OF THE BIBLIOGRAPHY

STUDIES ON PHYSICAL ENVIRONEMNTS

- Physical and historical geology studies
- Economic geology studies
- Soil studies
- Land typing

PLANT STUDIES

- Algae
- Lichens
- Fungi
- Vascular Plants
  - Ferns
  - Species ecology
- Landscape ecology
- Vegetation and community ecology
- Alpine and subalpine plant studies
- Alpine ecosystem studies
- Alpine range and biomass production
- Alpine ecosystem composition, structure and function
- Krumholz and ribbon forests
- Alpine and subalpine herbaceous community studies
- Forests
- Forest composition and structure
  - Lodgepole pine
  - Spruce-fir
  - Aspen
  - Miscellaneous studies of forest composition and structure
- Forest harvest methods
  - Lodgepole pine
  - Spruce-fir
- Miscellaneous forest harvest methods
- Forest regeneration
- Tree diseases
  - Insects
  - Dwarf mistletoe
  - Comandra blister rust
  - Miscellaneous tree disease studies
- Forest succession
- Timber harvest and water yield
- Tree physiology
- Forest processes
  - Nutrient cycling
  - Other stand level forest processes
  - Fire
- Mountain grasslands

ORGANIZATION OF THE BIBLIOGRAPHY (concl.)

TERRESTRIAL ANIMAL STUDIES

- Mammals (not TES species)
- American marten (Region 2 sensitive species)
- Birds
- Game birds (Not TES)
- Bird species and communities (Not TES)
- TES birds
- Birds and effects of timber harvest or livestock grazing
- Big game
  - Bighorn sheep
  - Mule deer
  - Elk
  - Moose
- Big game habitat

RIPARIAN AND AQUATIC SYSTEMS STUDIES

- Beavers
- Riparian ecosystems
- Amphibians and reptiles
- Invertebrates
- Fish
  - Colorado River cutthroat trout
  - Fish other than Colorado River cutthroat trout
- Streams - structure, function, condition
- High elevation lakes
- Water quality

WATER CHEMISTRY, ATMOSPHERIC POLLUTION AND CLIMATE CHANGE

RECENT MEDICINE BOW NATIONAL FOREST SPECIALIST REPORTS CONCERNING BIOLOGICAL DIVERSITY

PLANNING AND MONITORING (1985-1994)

HISTORICAL DESCRIPTIONS

APPENDIX 1

BIBLIOGRAPHY OF SCIENTIFIC STUDIES PERTAINING TO THE MEDICINE BOW NATIONAL FOREST

5/96

STUDIES ON THE PHYSICAL ENVIRONMENT

PHYSICAL AND HISTORICAL GEOLOGY STUDIES

Atwood, W.W. Jr. 1937. Records of Pleistocene glaciers in the Medicine Bow and Park Ranges. Journal of Geology 45(2): 663-673.

Banks, C.E. 1970. Precambrian gneiss at Sheephead Mountain, Carbon County, Wyoming, and its relationship to Laramide structure. University of Wyoming Contributions to Geology 9(2): 54-64.

Barton, R. 1974. Geology of the Kennaday Peak-Pennock Mountain area, Carbon County, Wyoming. Master's Thesis. University of Wyoming.

Blackwelder, E. 1926. Precambrian geology of the Medicine Bow Mountains. Geological Society of America Bulletin 37: 615-658.

Childers, M.O. 1957. The geology of the French Creek area, Albany and Carbon Counties, WY. Master's Thesis. University of Wyoming.

Donnelly, M.E. 1979. Petrology and structure of a portion of the Precambrian Mullen Creek mafic igneous complex, Medicine Bow Mountains, Wyoming. Master's Thesis. Colorado State University. Fort Collins, Colorado.

Evanoff, E. 1990. Early Oligocene paleovalleys in southern and central Wyoming: Evidence of high local relief on the late Eocene unconformity. Geology 18: 443-446.

Ferris, C.S. 1964. Petrology and structure of the Precambrian rocks of southeast of Encampment, Wyoming. Ph.D. Dissertation. University of Wyoming. Laramie, Wyoming.

Hausel, W.D. 1993a. Guide to the geology, mining districts, and ghost towns of the Medicine Bow Mountains and Snowy Range Scenic Byway. Geological Survey of Wyoming Public Information Circular No. 32, Laramie, Wyoming.

Hausel, W.D. 1993b. Mining history and geology of some of Wyoming's metal and gemstone districts: Wyoming Geological Association Jubilee Anniversary Field Conference Guidebook. Wyoming Geological Association.

Hausel, W.D.; Jones, R.W. 1984. Self-guided tour of the geology of a portion of southeastern Wyoming. Geological Survey of Wyoming, Laramie, Wyoming.

Hausel, W.D.; Glahn, P.R; Woodzick, T.L. 1981. Geological and geophysical investigations of kimberlite in the Laramie Range of southeastern Wyoming. Geological Survey of Wyoming Preliminary Report 18, Laramie, Wyoming.

Hills, F.A.; Houston, R.S. 1979. Early Proterozoic tectonics of the Central Rocky Mountains, North America. University of Wyoming Contributions to Geology 17 (2): 89-109.

Houston, R.S. 1961. The Big Creek pegmatite area, Carbon County, Wyoming. Geological Society of Wyoming Preliminary Report 1, Laramie, Wyoming.

—. 1992. Proterozoic mineral deposits near plate margins of the Archaen Wyoming Province, U.S.A. Precambrian Research 58: 85-87.

—. 1993a. Late Archaen and Early Proterozoic geology of Southeastern Wyoming, Volume 1. Geological Survey of Wyoming Memoir 5 pages 78-116, Laramie, Wyoming.

Houston, R.S. and others. 1968. A regional study of rocks of Precambrian Age in that part of the Medicine Bow Mountains lying in Southeastern Wyoming - with a chapter on the relationship between Precambrian and Laramide structure. Wyoming Geological Survey Memoir 1, Laramie, WY.

Houston, R.S.; Ebbett, B.E. 1977. Geological map of the Sierra Madre and Western Medicine Bow Mountains, southeastern Wyoming. Wyoming Geological Survey Map 1:125,000.

Houston, R.S.; Graff, P.J. 1991. Northern Medicine Bow Mountains geologic summary, Wyoming Geological Association 42nd Annual Field Conference Guidebook.

Houston, R.S.; Hills, A.; Gast, P.W. 1968. Regional aspects of structure and age of rocks of the Medicine Bow Mountains, Wyoming. Eighteenth Annual Meeting, Rocky Mountain Section Geological Society of America.

Houston, R.S.; Karlstrom, K.E. 1992. Geologic map of Precambrian metasedimentary rocks of the Medicine Bow Mountains, Albany and Carbon Counties, Wyoming. U.S. Geological Survey Miscellaneous Investigation Series Map I-2280.

Houston, R.S.; Karlstrom, K.E.; Graff, P.J; Flurkey, A.J. 1992. New stratigraphic subdivisions and redefinition of subdivisions of late Archaen and early Proterozoic metasedimentary and metavolcanic rocks of the Sierra Madre and Medicine Bow Mountains, Southern Wyoming. U.S. Geological Survey Professional Paper 1520.

Houston, R.S.; McCallum, M.E. 1965. Mullen Creek-Nash Fork shear zone, Medicine Bow Mountains, southeastern Wyoming. Geological Society of America Special paper 68.

Karlstrom, K.E. et al. 1981. A summary of the geology and uranium potential of Precambrian conglomerates in southeastern Wyoming. Volume 1. U.S. Department of Energy, Grand Junction, Colorado.

Karlstrom, K.E.; Flurkey, A.J.; Houston, R.S. 1983. Stratigraphy and depositional settings of the Proterozoic Snowy Range Pass Supergroup, southeastern Wyoming - Record of an early Proterozoic Atlantic-type cratonic margin. Geological Society of America Bulletin 94: 1257-1274.

Karlstrom, K.E.; Houston, R.S. 1979. Stratigraphy and uranium potential of early Proterozoic metasedimentary rocks in the Medicine Bow Mountains, Wyoming. Geological Survey of Wyoming Report of Investigations 13, Laramie, Wyoming.

Kiver, E.P. 1968. Geomorphology and glacial geology of the southern Medicine Bow Mountains, Colorado and Wyoming. University of Wyoming.

---. 1972. Two late Pinedale advances in the Southern Medicine Bow Mountians. Contributions to Geology 11(1): 1-8.

Knight, S.H. 1990. Illustrated geologic history of the Medicine Bow Mountains and adjacent regions. Geological Survey of Wyoming, Memoir 4, Laramie, Wyoming.

---. 1968. Precambrian stromatolites, bioherms and reefs in the lower half of the Nash Formation, Medicine Bow Mountains, Wyoming. Contributions to Geology 7 (2): 73-116.

---. 1953. Summary of the Cenozoic History of the Medicine Bow Mountains, WY. Guidebook for the 8th Annual Field Conference pages 65-80, Wyoming Geologic Association and University of Wyoming.

Knight, S.H.; Keefer, D.K. 1966. Preliminary report on the precambrian stromatolites on the Nash Formation, Medicine Bow Mountains, Wyoming. Contributions to Geology 5 (1): 1-11.

Lackey, L.L. 1965. Petrography of metavolcanic and igneous rocks of Precambrian age in the Huston Park area, Sierra Madre, Wyoming. Master's Thesis. University of Wyoming. Laramie, Wyoming.

Matus, I. 1958. The geology of the lower French Creek Area, Carbon County, WY. Master's Thesis. University of Wyoming.

Maughan, E.K.; Wilson, R.F. 1961. Pennsylvanian and Permian strata in southern Wyoming and northern Colorado. Guide to the Geology of Colorado, R. J. Weimer, and J. D. Haun, 34-42. Denver, CO: IN: Geological Society of America, Rocky Mountain Association of Geologists and Colorado Scientific Society.

McCallum, M.E. 1962. Geology of the east central portion of the Medicine Bow Mountains, southeastern Wyoming. PhD Thesis. University of Wyoming.

McCallum, M.E. 1962. Glaciation of Libby Creek Canyon, east flank of the Medicine Bow Mountains, Southeastern WY. Contributions to Geology 1(1): 21-29.

Mears, B. Jr. 1994. Glacial records in southeastern Wyoming: Precambrian tillites in the cores of the Medicine Bow Mountains and Sierra Madre. The Geological Survey of Wyoming (In Review).

---. 1953. Quaternary features of the Medicine Bow Mountains, WY. Geological Association Guidebook. Eighth Annual Field Conference pages 81-84.

---. 1962. Stone nets on Medicine Bow Peak, Wyoming. WY State Geologial Survey Short Notes 1: 48.

---. 1994. The structural-geomorphic history recorded in a wide Laramide uplift segmented by Neogene tectonism: The evolution of the Medicine Bow Mountains-Saratoga Valley-Sierra Madre region in Wyoming and adjacent Colorado. In Review.

Merry, R.D. 1963. Precambrian geology, shear zones and associated mineral deposits of the Hog Park area, Carbon County, Wyoming. Master's Thesis. University of Wyoming.

Michalek, D.D. 1952. Precambrian geology of Jelm Mountain, Albany County, Wyoming. Master's Thesis. University of Wyoming.

Moore, F.E. 1961. Summary of Cenozoic history, southern Laramie Range, Wyoming and Colorado. IN:Guide to the Geology of Colorado, R. J. Weimer, and J. D. Haun, 217-222. Denver, CO: Geological Society of America, Rocky Mountain Association of Geologists, Colorado Scientific Society.

Myers, W.G. 1958. Geology of the Six-Mile Gap area, Albany and Carbon Counties, Wyoming. Master's Thesis. University of Wyoming.

Oviatt, C.G. 1977. Glacial geology of the Lake Marie area, Medicine Bow Mountains. Contributions to Geology 16(1): 27-38.

Price, C. 1973. Glacial and drainage history of the upper Cow Creek drainage, Sierra Madre Range, Wyoming. Master's Thesis. University of Wyoming.

Schoen, R. 1953. Geology of the Cooper Hill District, Carbon County, Wyoming. Master's Thesis. University of Wyoming.

Snyder, G.L. 1980. Geological maps of the Park Range, southernmost Sierra Madre and Northernmost Gore Range, Grand, Jackson, and Routt Counties, Colorado. USGS Misc. Inv. Series No: I-112, I-113, I-114 Maps 1:48,000.

Snyder, G.L.; Hausel, W.D.; Klein, T.L.; Houston, R.S; Graff, P.J. 1989. Precambrian Rocks and Mineralization, southern Wyoming province: American Geophysical Union 18th International Geological Congress Field Trip Guidebook T332. Washington, D.C. American Geophysical Union 28th International Geological Congress.

Swetnam, M.N. 1961. Geology of the Pelton Creek area, Albany and Carbon Counties, Wyoming. Master's Thesis. University of Wyoming.

U.S. Geological Survey. 1985. Geological map of Wyoming. Reston, VA U.S. Geological Survey.

ECONOMIC GEOLOGY STUDIES

Beeler, H.C. 1905. Mining in the Grand Encampment Mining District, Carbon and Albany Counties, Wyoming. Office of the State Geologist, Cheyenne, Wyoming.

Beeler, H.C. 1906. Mineral and allied Resources of Albany County, Wyoming. Office of the State Geologist, Cheyenne, Wyoming.

Currey, D.R. 1965. The Keystone gold-copper prospect area, Albany County, Wyoming. Geological Survey of Wyoming Preliminary Report, Laramie, Wyoming.

Dersch, J.S. 1990. Snowy Range withdrawal. U.S. Bureau of Land Management Mineral Report WYW-115104.

Hausel, W.D. 1980a. The Douglas Creek gold-copper-platinum District, and placer diamonds in the Mullison Creek Area, Albany and Carbon Counties, Wyoming. Laramie, Wyoming, Wyoming Geological Association - Geological Survey of Wyoming - University of Wyoming Joint Conference Field Guide: Wyoming Geological Association - Geological Survey of Wyoming - University of Wyoming.

---. 1980b. Gold districts of Wyoming: Geological Survey of Wyoming Report of Investigations 23. Geological Survey of Wyoming, Laramie, Wyoming.

---. 1980c. Mines of the Centennial Ridge District, Albany County, Wyoming. Geological Survey of Wyoming, Mineral Report RM80-3, Laramie, Wyoming.

---. 1980d. South French Creek mineralized area, Albany and Carbon Counties. Geological Survey of Wyoming Mineral Report MR80-2, Laramie, Wyoming.

---. 1991. Geological Survey of Wyoming, Mineral Report MR91-1. Laramie, Wyoming.

---. 1992a. Geology and mineralization of the Copper Creek Area and nearby prospects, Encampment Mining District, Sierra Madre, Wyoming. Geological Survey of Wyoming unpublished Mineral Report MR92-2, Laramie, Wyoming.

---. 1992b. Economic geology of the Cooper Hill Mining District, Medicine Bow Mountains, Carbon County, Wyoming, 303- 314. Wyoming Geological Association 43rd Annual Field Conference Guidebook.

---. 1992c. Zinc-lead-copper-silver-gold-massive sulfide mineralization at the Broadway Mine, Sierra Madre, Wyoming. Geological Survey of Wyoming Mineral Report MR 92-4, Laramie, Wyoming.

---. 1994. Geology and mineralization of the Cooper Hill Mining District, Medicine Bow Mountains, Southeastern Wyoming. Geological Survey of Wyoming Report of Investigations No. 49, Laramie, Wyoming.

---. 1986a. Mineral deposits of the Encampment Mining District, Sierra Madre, Wyoming-Colorado. Geological Survey of Wyoming Report of Investigations No 37, Laramie, Wyoming.

---. 1986b. Mineral deposits of the Encampment District, Sierra Madre, Wyoming-Colorado. Rocky Mountain Association of Geologists 1986 Guidebook: 283-228.

Hausel, W.D.; Marlatt, G.G; Nielsen, E.L.; Gregory, R.L. 1994. Study of metals and precious stones in Southern Wyoming. Geological Survey of Wyoming Open-File Report 78-3, Laramie, Wyoming.

Hausel, W. D.; McCallum, M.E.; Roberts, J.T. 1985. The geology, diamond testing procedures, and economic potential of the Colorado- Wyoming Kimberlite Province - a review. Geological Survey of Wyoming Report of Investigations 31, Laramie, Wyoming.

Hausel, W. D.; Sutherland, W.M.; Gregory, E.M. 1993. Stream-sediment sample results in Search of Kimberlite Intrusives in Southeastern Wyoming. Geological Survey of Wyoming Open-File Report 88-11, Laramie, Wyoming.

Houston, R.S. 1992. Proterozoic mineral deposits near plate margins of the Archean Wyoming Province, U.S.A. Precambrian Research 58: 85-97.

Houston, R.S.; Karlstrom, J.E.; Graff, P.J.; Hausel, W.D. 1978. Radioactive quartz-pebble conglomerates of the Sierra Madre and Medicine Bow Mountains, Southeastern Wyoming. Geological Survey of Wyoming Open-File Report 78-3, Laramie, Wyoming.

Houston, R.S.; Graff, P.J.; Karlstrom, K.E.; Root, F.K. 1977. Preliminary report on radioactive conglomerate of middle Precambrian age in the Sierra Madre and Medicine Bow Mountains of southeastern Wyoming. U.S. Geological Survey open file report 77- 584.

Houston, R.S.; Karlstrom, K.E.; Lantheir, R.L.; Miller, R.R; Bigsby, P.R. 1983. Mineral Resource potential of the Snowy Range wilderness, Albany and Carbon Counties, Wyoming. U.S. Geological Survey Miscellaneous Field Studies Map MF-1596-A.

Houston, R.S.; Karlstrom, K.E.; Graff, P.J. 1979. Progress report on the study of radioactive quartz-pebble conglomerate of the Medicine Bow Mountains and Sierra Madre, southeastern Wyoming. U.S. Geological Survey Open File Report 79-1131.

Houston, R. S.; Schuster, J.F.; Ebbett, B.E. 1975. Preliminary report on distributions of copper and platinum group metals in mafic igneous rocks of the Sierra Madre, Wyoming. U.S. Geological Survey Open-File Report.

Kasteler, J.I.; Frey, E. 1949. Diamond drilling at the Rambler Copper Mine, Albany County. U.S. Bureau of Mines Report of Investigations 4544.

Kluender, S.E. 1982. Mineral Resources Investigation of the Savage Run Wilderness, Albany and Carbon Counties, Wyoming. U.S. Bureau of Mines Open-File Report MLA 75-82.

Loucks, R.R. 1976. Platinum-gold-copper mineralization, central Medicine Bow Mountains, Wyoming. Master's Thesis. Colorado State University. Fort Collins, Colorado.

---. 1991. Platinum-gold and vanadiferous magnetite mineralizations in the Early Proterozoic Lake Owen layered mafic intrusion, Medicine Bow Mountains, Wyoming, IN: Wyoming Geological Association 42nd Annual Field Conference Guidebook.

McCallum, M.E. 1968. The Centennial Ridge gold-platinum district, Albany County, Wyoming. The Geological Survey of Wyoming, Preliminary Report 7 Laramie, WY.

McCallum, M.E., Loucks, R. R.; Carlson, R.R; Colley, E.F.; Coerge, T.A. 1976. Platinum Metals associated with hydrothermal copper ores of the New Rambler Mine, Medicine Bow Mountains, Wyoming. Economic Geology 71: 1429-1450.

McCallum, M.E.; Orback, C.J. 1968. The New Rambler copper-gold-platinum district, Albany and Carbon Counties, Wyoming. The Geological Survey of Wyoming, Preliminary Report 8 Laramie, Wyoming.

McCallum, M.E.; Kluender, S.E. 1983. Mineral resources potential of the Savage Run wilderness, Carbon and Albany County, Wyoming. Geological Survey of Wyoming Preliminary Report 7, Laramie, Wyoming.

Neeham, A.B. 1942. Rambler Mine, Albany County Wyoming. U.S. Bureau of Mines War Minerals Report 17.

Segerstrom, K.; Weisner, R.C. 1977. Mineral resources of the Laramie Peak study area, Albany and Converse Counties, Wyoming. U.S. Geological Survey Bulletin 1397-B, U.S. Goct. Printing Office Washington, D.C.

Spencer, A.C. 1904. Copper deposits of the Encampment District, Wyoming. U.S. Geological Survey Professional Paper 25.

U.S. Bureau of Mines. 1942. War Minerals Report: Rambler Mine, Albany County, Wyoming. U.S. Bureau of Mines War Minerals Report 17.

USGS. 1983. Mineral resources potential and geology of the Huston Park Roadless Area, Carbon County Wyoming. 1983. 1:24,000 : U.S. Geological Survey Miscellaneous Field Studies map MF-1637.

Wied, O.J. 1960. Geology of the Encampment area, Carbon County, Wyoming. Master's Thesis. University of Wyoming, Laramie, Wyoming

SOIL STUDIES

Barndt, W. 1979. Soil survey of Battle Mountain (Technical Report). USDA Forest Service (Medicine Bow NF), Laramie, WY.

Doering, W.R. 1985. Soils related to park origin and dynamics in the Cinnabar Park Area, Medicine Bow Mountains. Master's Thesis. University of Wyoming.

Doering, W.R.; Reider, R.G. 1992. Soils of Cinnabar Park, Medicine Bow Mountains, Wyoming, U.S.A.:Indicators of park origin and persistence. Arctic and Alpine Research 24: 27-39.

Drever, J.I.; Joyce, G; Reiners, W.A; Knight, D.H. 1987. Laboratory tests of acid treatment to soils of the Medicine Bow Mountains, Wyoming. Report No. 2 to RMFRES in Fort Collins, CO USDA Forest Service Contract 28-K5-360, Laramie, WY.

Gurley, S.R. 1974. Paleopedology of the South French Creek - Middle Fork interfluve, Medicine Bow Mountains. Master's Thesis. University of Wyoming.

Hadley, K.; Hayater, M. 1982. A comparison of soil genesis and morphology between a subalpine grassland park and adjacent lodgepole pine forest, Medicine Bow Mountains, Wyoming. University of Wyoming, Class project Soils 612 Dept. of Plant Science.

Henkel, T.W.; Smith, W.K; Christensen, M. 1989. Infectivity and effectivity of indigeneous vesicular arbuscular mycorrhizal fungi from contiguous soils in southeast Wyoming. Phytologia 112: 205-214.

Hopper, R.W.; Walthall, P.M. 1987. Soil surveys for the Glacier Lakes and Lost Lakes Watersheds, Wyoming and Green Lakes and Niwot Ridge, Colorado U.S. Forest Service Contract No 28-K5- 359. USFS Unpublished Report RMFRES Library, Fort Collins, CO.

Jackson, W.N. 1957. Some soil characteristics of several grassland-timber transitions in the Big Horn Mountains and the Laramie Plains. Master's Thesis. University of Wyoming.

Kim, H.B. 1993. Soil morphology and genesis along an elevational transect, Snowy Range and Laramie Basin, WY. Master's Thesis. University of Wyoming.

King, J.S. 1964. Cooper Hill - a gravity slide in the northeastern Medicine Bow Mountains, Wyoming. University of Wyoming Contributions to Geology 3(1): 33-67.

Knight, D.H.; Reiners, W.A; Joyce, G.D; Drever, J.I. 1988. Effects of snowpack acidification on nutrient and aluminum outflow from lodgepole pine forest soils, Medicine Bow Mountains, Wyoming. Report No. 3 to RMFRES, Fort Collins, CO USDA Forest Service Contract 28-K5-360, Laramie, WY.

Knight, D.H.; Reiners, W.A.; Joyce, G.S.; Drever, J.I. 1989. Second year results on nutrient and aluminum outflow from lodgepole pine forest soils following snowpack acidification in the Medicine Bow Mountains, Wyoming. Report No. 7 to RMFRES in Forest Collins, CO. USDA Forest Service contract 28-K5-360, Laramie, WY.

Mason, M.L. 1976. The effects of commercial clearcut harvesting on the nutrient status of soil. Master's Thesis. University of Wyoming.

McCahon, T.J. 1990. Pleistocene soils in the Medicine Bow Mountains. PhD Dissertation. University of Wyoming.

McCahon, T.J.; Munn, L.C. 1991. Early and middle Pleistocene Paleosols in the Medicine Bow Mountains, Wyoming. Soil Science 152(6): 472-484.

McCahon, T.J.; Munn, L.C. 1991. Soils developed in the late Pleistocene till, Medicine Bow Mountains, Wyoming. Soil Science 152(5): 377-388.

Reider, R.G. 1975. Morphology and genesis of soils on the prairie divide deposit (Pre-Wisconsin), Front Range Colorado. Arctic and Alpine Research 7(4): 353-372.

---. 1977. Radiocarbon dates from carbonates of soils on Bull Lake and Pinedale tills of the Libby Creek Area, Medicine Bow Range, Wyoming. Contributions to Geology 15: 67-72.

---. 1983. A soil catena in the Medicine Bow Mountains, Wyoming, U.S.A., with reference to paleoenvironmental influences. Arctic and Alpine Research 15: 181-192.

Reider, R.G.; Gurley, S.R. 1975. Pre-Wisconsin paleosols and related soils on the South French Creek-Middle Fork (Little Laramie River) interfluve, Medicine Bow Mountains, Wyoming. Contributions to Geology 14: 41-49.

Reider, R.G.; Uhl, P.J. 1977. Soil differences within spruce-fir forested and century-old burned areas of Libby Flats, Medicine Bow Range, WY. Arctic and Alpine Research 9(4): 383- 392.

Reiners, W.A.; Drever, J.I.; Joyce, G.D.; Knight, D.H. 1987. Effects of snowpack acidification on solution chemistry of forest soils, Medicine Bow Mountains, Wyoming. Report No. 1 to RMFRES in Fort Collins, CO. USDA Forest Service Contract 28-K5- 360, Laramie, WY.

Reiners, W.A.; Drever, J.I.; Joyce, G.D.; Knight, D.H. 1989. Effects of snowpack acidification on solution chemistry of three subalpine soils, Glacier Lakes Ecosystem Experiments site, Medicine Bow Mountains, Wyoming. Report No.6 to Rocky Mountain Forest and Range Experiment Station USDA Forest Service COntract 28-K5-360, Laramie, WY.

Sansom, B.J. 1973. Morphology and analysis of soils in Wisconsin moraines of the Libby Creek area, Medicine Bow Mountains. Master's Thesis. University of Wyoming.

Sansom, B.R.; Reider, R.G. 1974. Soil development on Wisconsin moraines of the Libby Creek area, Medicine Bow Mountains, Wyoming. Contributions to Geology 13: 27-39.

Sears, P.B. 1934. Peat deposits in the Rocky Mountains. (Medicine Bow and Sierra Madre Mountains). Proceedings of the Oklahoma Academy of Science 15:39-40.

Somers, J.E. 1951. Some properties of the soil of spruce-fir forests in the Snowy Range, Wyoming. Master's Thesis. University of Wyoming.

Smith, D.R. 1966. Pot test of nutritive status of two high elevation soils in Wyoming. Journal of Range Management 19: 38- 40.

Smith, E.B. 1970. The evolution of carbon dioxide from the soil at four sites in the Snowy Range. Master's Thesis. University of Wyoming.

Uhl, P.J. 1974. Genetic comparison of soils in spruce-fir forested and burned areas of Libby Flats, Medicine Bow Mountains. Master's Thesis. University of Wyoming.

Weidler, B. (in Progress 1995). Edaphic characteristics of four Rocky Mountain soils under lodgepole pine. Master's Thesis. University of Wyoming.

LAND TYPING

Clarendon, D.T. 1991. Drainage basin differences in a land classification scheme on the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Marston, R.A.; Clarendon, D.T. 1988. Land systems inventory of the Medicine Bow Mountains and Sierra Madre, Medicine Bow National Forest, Wyoming. USDA, Laramie, WY.

Reiners, W.A; Thurston, R.C. 1995. Delineations of landtype associations within the Great Plains Physiographic Province of Wyoming. Final Report for the Bureau of Land Management Botany Department, University of Wyoming, Laramie, WY

CLIMATE

Mitchell, V.L. 1969. The regionalization of climate in montane areas. PhD Dissertation. University of Wisconsin.

STUDIES OF SPECIES AND ECOSYSTEMS

ALGAE, LICHENS, FUNGI

ALGAE

Couch, G.C. 1941. Hydrogen ion concentrations and diatoms in certain lakes of the Medicine Bow Mountains of Wyoming. University of Wyoming Publications 8(5):69-83.

Giles, G.H. 1933. Algae of the Medicine Bow Mountains in the vicinity of the University Summer camp. Master's Thesis. University of Wyoming.

Hensley, F.S., Jr. 1955. Precambrian algae of the Medicine Bow Range, Wyoming. Geological Society of America Bulletin 66: 1676.

Miller, L.R. 1936. Desmids of the Medicine Bow National Forest of Wyoming. University of Wyoming publications V(4):29-56.

LICHENS

Manning, B.P. 1936. Lichens of Albany County, WY. Master's Thesis. University of Wyoming.

FUNGI

Arenberg, F.F. 1939. The Agaricaceae of the Medicine Bow Mountains of Wyoming. Master's Thesis. University of Wyoming.

Cassidy, A.M. 1970. The Boletaceae of the Medicine Bow National Forest of Wyoming. Master's Thesis. University of Wyoming.

Miller, S.L. 1995. Functional diversity in fungi. Canadian Journal of Botany In press.

Miller, S.L.; Koo, C.D.; McClean, T.M. 1993. Persistence of basidiospores and sclerotia of ectomycorrhizal and saprotrophic basidiomycetes. Mycological Research 97: 141-149.

Miller, S.L.; Torres, P.; McClean, T.M. 1994. Persistence of basidiospores and sclerotia of ectomycorrhizal fungi and *Morchella* in soil. *Mycologia* 886: 89-95.

Rall, G. 1962. Soil fungi of the alpine zone of the Medicine Bow Mountains. Master's Thesis. University of Wyoming.

Williams, S.E. 1979. Vescicular-arbuscular mycorrhizae associated with Actinomycete-nodulated shrubs, *Cercocarpus montanus* RAF. and *Purshia tridentata* (Pursh)DC. Botanical Gazette 140: 115-119.

VASCULAR PLANTS

FERNS

Grillos, S.J. 1952. Ferns and fern allies of Wyoming. Master's Thesis. University of Wyoming.

SPECIES ECOLOGY

Brooks, A.C. 1962. An ecological study of *Cercocarpus montanus* and adjacent communities in part of the Laramie Basin. Master's Thesis. University of Wyoming.

Fertig, W.F. 1993. Survey of alpine plant species of special concern in the Medicine Bow Peak Special Botanical Area. The Nature Conservancy Report prepared for the Medicine Bow National Forest, Laramie, WY.

Fertig, W.; Refsdal, C.; Whipple, J. 1994. Wyoming Rare Plant Field Guide. The Wyoming Rare Plant Technical Committee. Wyoming Natural Diversity Database. Laramie, WY.

Kyte, C.R. 1975. An autecological study of *Vaccinium scoparium* in the Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

Ownbey, G.B. 1940. The genus *Astragalus* in southeastern Wyoming. Master's Thesis. University of Wyoming.

Robertson, W.D. 1983. Stem and clone ages in *Amelanchier* and *Symphoricarpos* in the Sierra Madre of southern Wyoming. Master's Thesis. University of Wyoming.

LANDSCAPE ECOLOGY

Baker, W.L. 1994. Landscape structure measurements for watersheds in the Medicine Bow National Forest using GIS analysis. Contract No. UW #5-35346. Unpublished report. Medicine Bow National Forest Laramie, WY.

Knight, D.H. 1994. Mountains and plains: The ecology of Wyoming landscapes. Yale University Press New Haven, CT.

Reed, R.A.; Johnson-Barnard, J.J.; Baker, W.L. (In press). Fragmentation of a forested Rocky Mountain landscape, 1950-1993. Biological Conservation.

Reed, R.A.; Johnson-Barnard, J; Baker, W.L. (Submitted). The contribution of roads to forest fragmentation in the Rocky Mountains. Conservation Biology.

VEGETATION CLASSIFICATION AND COMMUNITY ECOLOGY

Alexander, R.R. 1986. Classification of the forest vegetation of Wyoming. USDA Forest Service Research Note RM-466, Fort Collins, CO.

Alexander, R.R.; Hoffmann, G.E.; Wirsing, J.M. 1986. Forest vegetation of the Medicine Bow National Forest in Southeastern Wyoming: A habitat type classification. USDA, Fort Collins, CO.

Aslamy, M.N. 1965. Upland vegetation of the Pole Creek drainage, Pole Mountain Area, Wyoming. Master's Thesis. University of Wyoming.

Bennett, I.D. 1927. The seed-plants of the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Behan, M.J. 1958. The vegetation and ecology of Dry Park in the Medicine Bow Mountains of Wyoming. Master's Thesis. University of Wyoming.

Collins, E.I. 1984. Preliminary classification of Wyoming plant communities. The Nature Conservancy Wyoming Natural Heritage Program, Cheyenne, WY.

Collins, E.I. 1986. A bibliography of Wyoming plant studies. Prairie Naturalist

Current, F.B. 1984. The distribution and description of the vegetation of Battle Mountain as explained by abiotic factors. PhD Dissertation. University of Wyoming.

Dean, D.J.; Thomas, V.L.; Pool, D. 1995. A coarse-filter analysis of land cover types in the vicinity of the Medicine Bow National Forest, Wyoming. Contract with USDA Forest Service Region 2. Map (from GIS interpretation of Landsat imagery). Forest Science Department. Colorado State University, Fort Collins, CO.

Finzel, J. 1960. Species lists from Libby Flats, summit area of Pole Mountain and Laramie Plains 1959-60. Class report. University of Wyoming.

Fertig, W. 1992. Checklist of the the vascular plants of the Medicine Bow Mountains. (Update of Nelson, 1984). Wyoming Natural Diversity Database internal report. THE Nature Conservancy. Laramie, WY.

Gartner, F.R. 1967. Microcolimate, vegetation and soils along a vertical gradient on Elk Mountain, Wyoming. Master's Thesis. University of Wyoming.

Haines, J.A.; Regan, C.M. 1994. Vascular Plants of GLEES. The Glacier Lakes Ecosystem Experiments Site, USDA Forest Service General Technical Report RM-249.

Hanna, L.A. 1934. The major plant communities of the headwater area of the Little Laramie River, Wyoming. Wyoming University Publications in Science 1: 243-266.

Hartman, R.H. 1992. The Rocky Mountain Herbarium, associated floristic inventory and the Flora of the Rocky Mountains Project. Botany of Idaho - Boone Symposium, Caldwell, ID, 27 March 1992.

Hoff, C.C. 1957. A comparison of soil, climate, and biota of conifer and aspen communities in the central Rocky Mountains. American Midland Naturalist 58: 115-140.

Holliday, J.N. Jr. 1965. Vascular plants of a sedge meadow, Pole Mountain, Wyoming. Master's Thesis. University of Wyoming.

Jacoby, P.W., Jr. 1971. Interrelationships of vegetation and environmental factors on a mountain watershed in southeastern Wyoming. PhD Dissertation. University of Wyoming.

Jankovsky-Jones, M. 1995. Ecological evaluations for potential research natural areas within the Medicine Bow National Forest, WY. Reports on 12 areas: Battle Mountain, Standard Park-Bogs, E. Fork Encampment River, Platte River-Ridge, Many Ponds, Ground Moraine, Threemile, Ribbon Forest, Sheep Mountain, LaBonte Canyon, Big Bear Canyon, Old Maid's Draw. Wyoming Natural Diversity Database - THE Nature Conservancy. Laramie, WY

Johnson, R.E. 1950. An ecological analysis of a mountain mahogany community. Master's thesis. University of Wyoming.

Johnston, B.C. 1987. Plant associations of Region 2: Potential plant communities of Wyoming, South Dakota, Nebraska, Colorado and Kansas. USDA Forest Service Region 2 R2-ECOL-87-2, Lakewood, CO.

Johnston, S.L. 1984. Multi-level vegetation classification using Landsat MSS and collateral data: Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

Jones, G.P. 1992. A preliminary classification of riparian vegetation types of the Medicine Bow Range and the Sierra Madre. USDA Forest Service Medicine Bow National Forest, Laramie, WY.

Jones, W.B. 1972. A vegetation study of the Sheep Mountain watershed, Albany County, Wyoming. PhD Dissertation. University of Wyoming.

Kastning, N. 1992. A floristics survey of the Park and Sierra Madre Ranges, Colorado and Wyoming. Master's Thesis. University of Wyoming.

Kettler, S. April, 1994. Routt National Forest riparian vegetation classification Preliminary Report. Colorado Natural Heritage Program, Boulder, CO.

Larson, L.L. 1978. Vegetative variablity along a gradient from lodgepole pine-spruce-fir. PhD Dissertation. Colorado State University.

Miles, S.R. 1973. Vegetative history and boundary stability of park areas in the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Miles, S.R.; Singleton, P.C. 1975. Vegetational history of Cinnabar Park in Medicine Bow National Forest. Soil Science Society of America Proceedings, 1204-1208.

Myers, W.E. 1969. Relationship of vegetation to geologic formation along Sheep Mountain, Albany County, Wyoming. Master's Thesis. University of Wyoming.

Nelson, B.E. 1974. Vascular Plants of the Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

Phillips, C.M. 1977. Willow carrs of the upper Laramie River Valley, Colorado. Master's Thesis. Colorado State University.

Reeves, T.L. 1984. An evaluation of video image processing and density slicing for sampling vegetative cover within quadrats. Master's Thesis. University of Wyoming.

Reiners, W.A.; Strong, L.; Matson, P.A.; Burke, I.C.; Ojima, D.S. 1989. Estimating biogeochemical fluxes across sagebrush-steppe landscapes with Thematic Mapper imagery. Remote Sensing 28: 121-129.

Rodgers, D.E. 1981. Ecological effects of grazing management systems on sagebrush-grassland vegetation of south-central Wyoming. Master's Thesis. University of Wyoming.

Starr, C.R. 1974. Subalpine meadow vegetation in relation to environment at Headquarters Park, Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

Story, M. 1972. A phytosociological analysis of the Nash Fork watershed. Unpublished paper. Dept. of Botany. University of Wyoming.

Vale, T.R. 1978. Tree invasion of Cinnabar Park in Wyoming. American Midland Naturalist 100: 277-284.

Wirsing, J.M. 1973. Forest vegetation of Southeastern Wyoming. PhD Dissertation. Washington State University.

Wyoming Natural Diversity Database. 1992. Wyoming plant community classification. Wyoming Natural Diversity Database of the The Nature Conservancy, Laramie, WY.

ALPINE AND SUBALPINE PLANT STUDIES

Billings, W.D.; Clebsch, E.E.C.; Mooney, H.A. 1961. Effect of low concentration of carbon dioxide on photosynthesis rates of two races of *Oxyria*. Science 133: 1834.

Billings, W.D.; Godfrey. P.J. 1967. Photosynthetic utilization of internal carbon dioxide by hollow-stemmed plants. Science 158: 121-123.

Bliss, L.C. 1956. Transpiration rates of arctic and alpine shrubs. Ecology 41 (2): 386-389.

Caldwell, M.L.H. 1963. *Erythronium*: Comparative phenology of alpine and deciduous forest species in relation to environment. Master's Thesis. Duke University.

---. 1969. *Erythronium*: comparative phenology of alpine and deciduous forest species in relation to environment. American Midland Naturalist 82: 543-558.

Clebsch. E.E.C. 1960. Comparative morphological and physiological variation in arctic and alpine populations of *Trisetum spicatum* (Wyoming to Alaska). PhD Dissertation. Duke University.

Clebsch, E.E.C.; Billings, W.D. 1976. Seed germination and vivipary from a latitudinal series of populations of the arctic-alpine grass *Trisetum spicatum*. Arctic and Alpine Research 8: 255-262.

Daubenmire, R.E. 1941. Some ecological features of the subterranean organs of alpine plants. Ecology 22(4): 370-378.

Geller, G.N.; Smith, W.K. 1982. Influence of leaf size, orientation and arrangement on temperature and transpiration in three high elevation large-leafed herbs. *Oecologia* 53: 227-234.

Hamerlynk, E. 1992. Subnivean and emergent growth, morphology, and physiology of *Erythronium grandiflorum* in relation to snow melt dynamics in the subalpine forest, Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

Hamerlynk, E.P.; Smith, W.K. 1994. Subnivean and emergent microclimate, photosynthesis, and growth in *Erythronium grandiflorum* Pursh, a snowbank geophyte. Arctic and Alpine Research 26: 21-28.

Jordan, D.N.; Smith, W.K. In press (1994). Microclimate factors influencing the frequency and duration of growth season frost for subalpine plants. Agricultural Forest Meterology.

---. In press (1994). Radiation frost susceptibility and the association between sky exposure and leaf size. Oecologia.

Knapp, A.K. 1988. Non-steady-state ecophysiological response in subalpine plants to variable sunlight. PhD Dissertation. University of Wyoming.

Knapp, A.K.; Smith, W.K. 1990. Contrasting stomatal and photosynthetic responses to variable sunlight in two subalpine herbs. American Journal of Botany 77: 226-231.

---. 1988. Effect of water stress on stomatal and photosynthetic responses to cloud pattern in subalpine plants. American Journal of Botany 75: 851-858.

---. 1991. Gas exchange responses to variable sunlight in two Sonoran Desert herbs: comparison with subalpine species. Botanical Gazette 152(2): 269-274.

Knapp, A.K.; Smith, W.K.; Young, D.R. 1989. Importance of intermittent shade to the ecophysiology of subalpine herbs. Functional Ecology 3: 753-758.

Knapp, A K.; Smith, W.K. 1989. Influence of growth form on ecophysiological responses to variable sunlight in subalpine plants. Ecology 70: 1069-1082.

---. 1987. Stomatal and photosynthetic responses to sun/shade transitions in subalpine plants: influence on water use efficiency. Oecologia 74: 527-533.

Mitchell, K.K. 1994. Influence of light and nitrogen availability on carbon acquisition and allocation in *Epilobium angustifolium*. Master's Thesis. University of Wyoming.

Mooney, H.A. 1958. Carbohydrate economy in relation to growth of certain alpine plants in Wyoming. Master's Thesis. Duke University.

Mooney, H.A. 1960. Comparative physiological ecology of arctic and alpine populations of *Oxyria digyna* (Wyoming to Alaska). PhD Dissertation. Univerisity of Wyoming.

---. 1963. Physiological ecology of coastal, subalpine and alpine populations of *Polygonum bistortoides*. Ecology 44 (4): 812-816.

Mooney, H.A.; Billings, W.D. 1960. The annual carbohydrate cycle of alpine plants as related to growth. American Journal of Botany 47: 594-598.

Mooney, H.A.; Billings. W.D. 1961. Comparative physiological ecology of arctic and alpine populations of *Oxyria dignya*. Ecological Monographs 31: 1-29.

Rochow, T. F. 1970. Ecological investigations of *Thlaspi alpestre* along an elevational gradient in the Central Rocky Mountains. Ecology 51: 649-656.

---. 1967. The ecology of *Thlaspi alpestre* in the Central Rocky Mountains along ecological gradients. PhD Dissertation. Duke University.

---. 1969. Growth, caloric content and sugars in *Caltha leptosepala* in relation to alpine snowmelt. Bulletin Torrey Botanical Club 96: 689-698.

---. 1964. Seasonal caloric and carbohydrate content of *Caltha leptosepala*, an alpine snowbank plant. Master's Thesis. Duke University.

Reynolds, D.N. 1984. Alpine annual plants: phenology, germination, photosynthesis, and growth of three Rocky Mountain species. Ecology 65(3): 759-766.

Reynolds, D. 1982. The physiological and population ecology of alpine annual plants in the Rocky Mountains (Montana and Wyoming). PhD Dissertation. University of Wyoming.

Reynolds, D.D. 1984. Populational dynamics of three annual species of alpine plants in the Rocky Mountains. Oecologia 62: 250-255.

Scott, D.; Hillier, R.D; Billings, W.D. 1970. Correlation of CO_2 exchange with moisture regime and light in some Wyoming subalpine meadow species. Ecology 51: 701-702.

Smith, W.K. 1981. Temperature and water relations patterns in subalpine understory plants. Oecologia 48: 353-359.

Smith, W.K.; DeLucia, E.H.; Knapp, A.K. 1987. Environmental limitations to photosynthesis in subalpine plants of the Rocky Mountains. IN: Management of Subalpine Forests: Building on 50 Years of Research, 199-206. Silver Creek, CO, July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM- 149.

Smith, W.K.; Geller, G.N. 1979. Plant transpiration and high elevations; theory, field measurement, and comparisons with desert plants. Oecologia 41:109-122.

Smith, W. K.; Knapp, A.K.; Pearson, J.A.; Varman, J.H.; Yavitt, J.B.; Young, D.R. 1983. Influence of microclimate and growth form on plant temperatures of early spring species in a high elevation prairie community. American Midland Naturalist 109: 681-687.

Stingel, M.G. 1965. Photoperiodic response of selected plants of the Medicine Bow Mountains of Wyoming. Master's Thesis. University of Wyoming.

White, R.W. 1973. Silver content of soil and plants of the Medicine Bow National Forest and its influence on plant growth. Master's Thesis. University of Wyoming.

Williams, L.D. 1970. Life-form characteristics of *Androsace septentrionalis*, an arctic-alpine "annual", in southeastern Wyoming. Master's Thesis. Duke University.

Young, D.R. 1979. The influence of microhabitat on the water and photosynthetic relations of two understory congeners: *Arnica cordifolia* and *Arnica latifolia*. Master's Thesis. University of Wyoming.

---. 1982. Intraspecific variation in the physiological ecology of the understory herb, *Arnica cordifolia*. PhD Dissertation. University of Wyoming.

Young, D.R.; Burke, I.C.; Knight, D.H. 1985. Water relations of high-elevation phreatophytes in Wyoming. American Midland Naturalist 114: 384-392.

Young, D. R.; Smith, W.K. 1983. Effect of cloudcover on photosynthesis and transpiration in the subalpine understory species *Arnica latifolia*. Ecology 64: 681-687.

---. 1979. Influence of sunflecks on the temperature and water relations of two subalpine understory congeners. Oecologia 43: 194-205.

---. 1980. Influence of sunlight on photosynthesis, water relations, and leaf structure in the understory species *Arnica cordifolia*. Ecology 60: 1380-1390.

---. 1982. Simulation studies of the influence of understory location on transpiration and photosynthesis of *Arnica cordifolia* on clear days. Ecology 63: 1761-1770.

ALPINE ECOSYSTEM STUDIES

ALPINE RANGE AND BIOMASS PRODUCTION

Blankenship, J.O. 1964. Indirect estimation of standing crop for selected alpine species. Master's Thesis. University of Wyoming.

Blankenship, J.O.; Smith, D.R. 1966. Indirect estimation of standing crop. Journal of Range Management 19: 74-77.

Johnson, W.M. 1961. The ecology of alpine and subalpine ranges in Wyoming as related to use by game and domestic sheep. Master's Thesis. University of Wyoming.

---. 1962. Vegetation of High Altitude Ranges in Wyoming as Related to Use by Game and Domestic Sheep. University of Wyoming Agric. Exp. Station Bull #387, Laramie, WY.

Lester, J.E. 1972. The effects of livestock grazing on the response of high mountain vegetation determined from a study of net production and utilization. PhD Dissertation. University of Wyoming.

Schwan, H.E.; Costello, D.F. 1951. The Rocky Mountain Alpine Type: Range Conditions, Trends and Land Use (A Preliminary Report). USDA Forest Service, Unpublished (RMFRES Library), Fort Collins, CO.

Scott, D. 1963. The standing crop and productivity of alpine tundra in relation to environmental factors. PhD Dissertation. Duke University.

Scott, D.; Billings, W.D. 1964. Effects of environmental factors on standing crop and productivity of an alpine tundra. Ecological Monographs 34: 243-270.

Smith, D.R. 1969. *In vitro* digestibility of alpine forages in Wyoming. Rocky Mountain Forest and Range Experiment Station Research Note 145. Fort Collins, CO.

Smith, D.R.; Alley, H.P. 1966. Chemical control of alpine avens. Journal of Range Management 196(6): 376-378.

Smith, D.R.; Johnson, W.M. 1965. Vegetative characteristics on a high altitude sheep range in Wyoming. Bull 430 Agricultural Experiment Station, University of Wyoming, Laramie, WY.

Strasia, C.A.; Thorn, M.; Rice, R.W; Smith, D.R. 1970. Grazing habits, diet and performance of sheep on alpine ranges. Journal of Range Management 23:201-208.

Thilenius, J.F. 1975. Alpine Range Management in the Western United States - Principles, Practices and Problems. USDA Forest Service Research Paper RM-175, Fort Collins, CO.

Thilenius, J.H. 1972. Environmental factors affecting the species composition and productivity of alpine tundra on Medicine Bow Peak and high subalpine meadows on Libby Flats. Unpublished Interim Report for The Medicine Bow Ecology Project RMFRES files.

Thilenius, J.F. 1975. Plant production of three high elevation ecosystems. The Medicine Bow Ecology Project, 60-75. Laramie, WY: University of Wyoming.

Thilenius, J.F.; Brown, G.R. 1976. Effect of 2,4-D on digestibility and production of subalpine herbage. Journal of Range Management 29(1): 63-65.

Thilenius, J.F.; Smith, D.R.; Brown, G.R. 1974. The effects of 2,4-D on species composition and production of an alpine plant community in Wyoming. Journal of Range Management 27 (2): 140- 142.

Thilenius, J.F.; Brown, G.R. 1987. Herded vs. unherded sheep grazing systems on an alpine range in Wyoming. USDA Forest Service General Technical Report RM-147 Fort Collins, Colorado.

Thorn, M.B. 1969. Botanical composition of sheep diets on an alpine range. Master's Thesis. University of Wyoming.

ALPINE ECOSYSTEM COMPOSITION, STRUCTURE, AND FUNCTION

KRUMHOLZ AND RIBBON FORESTS

Earle, C.J. 1993. Forest dynamics in a forest-tundra ecotone, Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Washington, Seattle, WA.

Hadley, J.L. 1986. Effects of wind of leaf dessication and mortality in Wyoming timberline conifers: influence of krummholz growth forms. PhD Dissertation. University of Wyoming.

Hadley, J.L.; Smith, W.K. 1987. Influence of krummholz mat structure on microclimate on needle physiology and survival. Oecologia 73: 82-90.

---. 1986. Wind effects on needles of timberline conifers; seasonal influence on mortality. Ecology 67: 12-19.

---. 1989. Wind erosion of leaf surface wax in alpine timberline conifers. Arctic and Alpine Research 21: 392-398.

ALPINE AND SUBALPINE HERBACEOUS COMMUNITY STUDIES

Billings, W.D. 1979. Alpine ecosystems of western North America. Special Management Needs of Alpine Ecosystems. Editor D. Johnson, pages 6-21. Denver, CO: Range Management Society.

---. 1988. Alpine plant communities and vegetation gradients. IN: North American terrestrial vegetation. Editors M. G. Barbour, and W. D. Billings, Chapter 13 pages 391-420. New York: Cambridge University Press.

---. 1969. Vegetational pattern near alpine timberline as affected by fire-snowdrift interactions. Vegetatio 19: 192-207.

Billings, W.D.; Bliss, L.C. 1959. An alpine snowbank environment and its effects on vegetation, plant development, and productivity. Ecology 40: 388-397.

Billings, W.D.; Clebsch, E.E.C.; Mooney, H.A. 1966. Photosynthesis and respiration rates of Rocky Mountain alpine plants under field conditions. American Midland Naturalist 75: 34-44.

Billings, W.D.; Mooney, H.A. 1959. An apparant frost hummock-sorted polygon cycle in the alpine tundra of Wyoming. Ecology 40: 16-20.

---. 1968. The ecology of arctic and alpine plants. Biological Reviews 43: 481-530.

Bliss, L.C. 1956. A comparison of plant development in microenvironments of arctic and alpine tundras. PhD Dissertation. Duke University.

---. 195 . A comparison of plant development in microenvironments of arctic and alpine tundras. Ecological Monographs 26:303-337.

Bonham, C.D.; Ward, R.T. 1970. Phytosociological relationships in alpine tufted hairgrass (*Deschampsia caespitosa*) (L. Beauv.) meadows. Arctic and Alpine Research 2 (4): 267-275.

Cain, S.A. 1943. Sample-plot techniques applied to alpine vegetation in Wyoming. American Journal of Botany 30: 240-247.

Godfrey, P. 1969. Factors influencing the lower limits of alpine plants in the Medicine Bow Mountains of Southeastern Wyoming. PhD. Duke University.

Hill, T.H. 1959. Water content of alpine plants in the Medicine Bow Mountains of Wyoming. Master's Thesis. University of Wyoming.

Hillier, R.D. 1970. The influence of water on growth and development of alpine plants in the Medicine Bow Range, Wyoming. PhD Dissertation. Duke University.

Jordan, D.N.; Smith, W.K. 1994. Energy balance analysis of nighttime leaf temperatures and frost formation in a subalpine environment. Agricultural Forest Meterology 71: 359-372.

Knight, D.H. et al. 1975. The Medicine Bow ecology project : The potential sensitivity of various ecosystem components to winter precipitation management in the Medicine Bow Mountains, Wyoming (Final Report). University of Wyoming in cooperation with the Rocky Mountain Forest and Range Experiment Station, U.S. Forest Service and the Wyoming Water Resources Research Institute Contract No. 14-06-D-7198, Laramie, WY.

Mastel, J. 1991. List of potential species for the Mirror Lake/ Lake Marie Reconstruction project. Specialist report Medicine Bow National Forest Brush Creek RD, Laramie, WY.

Musselman, R.C. 1994. The Glacier Lakes Ecosytem Experiment Site: an alpine global change research study area. U.S. Forest Service General Technical Report RM-249, Fort Collins, CO.

Oberbauer, S.F.; Billings, W.D. 1981. Drought tolerance and water use by plants along an alpine topographic gradient. Oecologia 50: 325-331.

Peterson, K.M.; Billings, W.D. 1982. Growth of alpine plants under controlled drought. Arctic and Alpine Research 14 (3): 189-194.

Smith, D.R. 1969. Vegetation, soils and their interrelationships at timberline in the Medicine Bow Mountains, WY. University of Wyoming Agric. Expt. Sta. Science Monograph #17, Laramie, WY.

Thilenius, J.F. 1970. A review of ecological studies in the alpine tundra and subalpine grasslands of the Medicine Bow Mountains. USDA Forest Service - Unpublished Report RMFRES in Laramie, WY, Laramie, WY.

FORESTS

FOREST COMPOSITION AND STRUCTURE

LODGEPOLE PINE

Almeida, R.M. 1969. Understory vegetation of lodgepole pine. Master's Thesis. University of Wyoming.

Fox, J. 1940. A study of lodgepole pine stands in southern Wyoming: with reference to Cajander's theory of forest site types. Master's Thesis. University of Wyoming.

Moore, M.B. 1981. Geographic variation in lodgepole pine in the Central Rocky Mountains. PhD Dissertation. Colorado State University. Fort Collins, CO.

Moore, S.L. 1912. Lodgepole pine in Colorado and Wyoming. Unpublished manuscript USDA Forest Service RMFRES, Fort Collins, CO.

Pearson, J.A. 1982. Biomass distribution and ecosystem development in lodgepole pine forests of the Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Wyoming.

Pearson, J.A.; Fahey, T.J; Knight, D.H. 1984. Biomass and leaf area in contrasting lodgepole pine forests. Canadian Journal of Forest Research. 14: 259-265.

SPRUCE-FIR

Aplet, G.H.; Laven, R.D.; Smith, F.W. 1988. Patterns of community dynamics in Colorado Engelmann spruce-subalpine fir forests (Cache La Poudre, Laramie River headwaters). Ecology 69: 312-319.

Oosting, H.J.; Reed, J.F. 1952. Virgin spruce-fir of the Medicine Bow Mountains, Wyoming. Ecological Monographs 22(2): 70-91.

ASPEN

Baker, F.S. 1925. Aspen in the Central Rocky Mountain Region. USDA Bulletin 1291.

Buttery, R.F. et al. 1977. Stand characteristics to meet the major uses of aspen. USDA Forest Service unpublished Report - Rocky Mountain Region, Lakewood, CO.

Montgomery, D.H. 1959. A phenological study of aspen in the Medicine Bow Mountains. Unpublished paper - Botany Dept. University of Wyoming.

Severson, K. 1963. A description and classification, by composition, of the aspen stands in the Sierra Madre Mountains, Wyoming. Master's Thesis. University of Wyoming.

Severson, K.E. 1965. A description and classification, by composition, of the aspen stands in the Sierra Madre Mountains, Wyoming. Wyoming Range Management 214: 99-105.

Strain, B.R. 1961. Physiological ecology of *Populus tremuloides*. Master's Thesis. University of Wyoming.

Strain, B.R.; Johnson, P.L. 1963. Corticular photosynthesis and growth in *Populus tremuloides*. Ecology 44(3): 581-584.

Turlo, J.B. 1963. An ecological investigation of *Populus tremuloides* at two elevation levels in the Medicine Bow National Forest of Wyoming. Master's Thesis. University of Wyoming.

MISCELLANEOUS STUDIES OF FOREST COMPOSITION AND STRUCTURE

Bergen, J.D. 1971. Vertical profiles of windspeed in a pine stand. Forest Science 17: 314-321.

Billings, W.D. 1990. The mountain forests of North America and their environments. Plant Biology of the Basin and Range. Editors C. B. Osmond, G. M. Hidy, and L. Pitelka, Chapter 3 pages 47-87. New York: Springer-Verlag.

Cary, L.E. 1966. A study of forest margins. Master's thesis. University of Wyoming.

Choate, G.A. 1963. The Forests of Wyoming. USDA Forest Service Resource Bulletin INT-2, Ogden, UT.

Gary, H.L. 1978. The vertical distribution of needles and branchwood in thinned an unthinned 80-year old lodgepole pine. Northwest Science 52(4): 303-309.

Green, A.W.; Conner, R.C. 1989. Forests in Wyoming. USDA Forest Service General Technical Report INT-61, Ogden, Utah.

Hershey, T.; Sobczak, C. 1991. Guidelines for marking snags and replacements. Specialist Report - Medicine Bow National Forest, Hayden Ranger District Encampment, WY.

Knight, D.H. 1987. Ecosystem studies in the subalpine coniferous forests of Wyoming. Management of subalpine forests: Building on 50 years of research, Silver Creek, CO, 6 July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM- 149.

---. 1991. Pine Forests: A comparative overview of ecosystem structure and function. IN: Coniferous forest ecology from an international perspective. N. Nakagoshi, and F. B. Golley, pp. 121-135. The Hague, Netherlands: SBP Academic Publishing.

Moyer, J.F. 1928. The ecological factors that govern the habit, growth and distribution of the gymnosperms in south-eastern Wyoming. Master's Thesis. University of Wyoming.

Rogers, B.S. 1974. The regulation of understory pattern in lodgepole pine and spruce-fir forests, Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

FOREST HARVEST METHODS

LODGEPOLE PINE

Alexander, R.R. 1965. Growth of thinned young lodgepole pine in Colorado. Journal of Forestry (Fraser Experimental Forest) 63 (6): 429-433.

---. 1966. Harvest cutting old-growth lodgepole pine in the Central Rocky Mountains. Journal of Forestry (Fraser Experimental Forest) 64: 113-116.

---. 1975. Partial cutting in old-growth lodgepole pine. USDA Forest Service Research Paper RM-136, Fort Collins, CO.

---. 1960. Thinning lodgepole pine in the central Rocky Mountains. Journal of Forestry 58: 99-104.

---. 1956. Two methods of thinning young lodgepole pine in the Central Rocky Mountains (Fraser Experimental Forest). Journal of Forestry 54 (2): 99-102.

Alexander, R.R.; Edminster, C.B. 1980. Lodgepole pine management in the Central Rocky Mountains. Journal of Forestry 78 (4): 196-201.

Benson, R.E. 1982. Management consequences of alternative harvesting and residue treatment practices - lodgepole pine. USDA Forest Service General Technical Report INT-132, Odgen, Utah.

Berntsen, C.M. 1973. Management conflicts in lodgepole pine. Management of lodgepole pine ecosystems, David Baumgartner, 503- 515. Pullman, WA, October 1973. Pullman, WA: Washington State Univ.

Cole, D.M.; Edminster, C.B. 1984. Growth and yield of lodgepole pine. Lodgepole Pine: The species and its management, D. M. Baumgartner, R. G. Krebill, J. T. Arnott, and G. F. Weetman, pages 261-290. Spokane, WA, May 1984. Pullman, WA: University of WA.

Lexen, B. 1949. Alternate clear-strip cutting in the lodgepole pine type. USDA Forest Service Station Paper Number 1, Fort Collins, CO.

Raisanen, G.S. 1985. Modeling lodgepole pine site productivity in Colorado and Southern Wyoming. PhD Dissertation. Colorado State University.

Ribbens, E. 1988. Understory biomass, litterfall, and individual tree response to thinning in a Wyoming lodgepole pine forest. Master's Thesis. University of Wyoming.

SPRUCE-FIR

Alexander, R.R. 1977. Cutting methods in relation to resource use in Central Rocky Mountain spruce-fir forests (Fraser Experimental Forest). Journal of Forestry 75: 395-400.

---. 1963. Harvest cutting old-growth mountain spruce-fir in Colorado (Fraser Experimental Forest). Journal of Forestry 61(2): 115-119.

---. 1964. Minimizing windfall around clear cuttings in spruce-fir forests. Forest Science (Routt, A-R-Colorado) 10 (2): 130- 142.

Alexander, R.R.; Edminster, C.B. 1980. Management of spruce-fir in even-aged stands in the Central Rocky Mountains. USDA Forest Service Research paper RM-217, Fort Collins, CO.

---. 1977. Uneven-aged management of old growth spruce-fir forests: Cutting methods and stand structure goals for the initial entry. USDA Forest Service Research Paper RM-186, Fort Collins, CO.

Averill, C.C. 1964. A report on the condition of the spruce-fir cutover areas of the Rocky Mountain Region. RMFRES library Fort Collins, CO, Unpublished Report.

Shepperd, W.D.; Alexander, R.R. 1983. Silviculture of spruce-fir forests in the Central Rockies. USDA Forest Service Rocky Mountain Forest and Range Experiment Station US Govt. Printing Office 1983-677-885, Fort Collins, CO.

MISCELLANEOUS FOREST HARVEST METHODS

Alexander, R.R. 1974. Silviculture of central and southern Rocky Mountain Forests: a summary of the status of our knowledge by timber types. USDA Forest Service Research Paper RM-120, Fort Collins, CO.

---. 1974. Silviculture of subalpine forests in the central and southern Rocky Mountains: The status of our knowledge. USDA Forest Service Research Paper RM-121, Fort Collins, CO.

Berntsen, C.M. 1971. Forest Management In Wyoming. USDA Forest Service Report.

Delay, T. 1990. Information paper: Silvicultural options for managing trees on the Medicine Bow National Forest. USDA Forest Service Medicine Bow National Forest Unpublished report.

Environmental Action Organization. 1972. Some ecological aspects of clearcutting in the Medicine Bow Forest, Wyoming. National Science Foundation - Student Originated Studies Program, Laramie, WY.

Fudge, C.W. 1987. Forest inventory tables - 1987 RPA. USDA FS Region 2 Regional Office, Lakewood, CO.

Kanaly, J. 1970. Long-range effect of logging operations on the south fork of French Creek, Carbon County. Wyoming Game and Fish Department Administrative Report, Cheyenne, Wyoming.

Kanaly, J.; Oberholzer, M. 1979. Long-range effect of logging operations on the south fork of French Creek, Carbon County. Wyoming Game and Fish Department Administrative Report - 5079-08- 5903, Cheyenne, WY.

Ward, A.L. 1979. Clearcut seeding study. USDA Forest Service Unpublished Report for Foxpark Ranger District, Medicine Bow National Forest.

Weisberg, P.J. 1992. Logging activity in the Medicine Bow National Forest: changes in landscape structure over a thirty year period. Unpublished paper from G&R 5060 Landscape Ecology (Graduate Seminar), University of Wyoming, Laramie, WY.

Zymj, P.M. 1989. Study of historical outputs, timber and elk, Medicine Bow National Forest. Unpublished Report by U. WY. Graduate Intern, Laramie, WY.

FOREST REGENERATION

Bates, C.G.; Hilton, H.C; Krueger, T. 1929. Experiments in the silvicultural control of natural reproduction of lodgepole in the Central Rocky Mountains. Journal of Agricultural Research 38(4): 229-243.

Cook, J. 1954. Some aspects of the reproduction of Engelmann spruce. Master's Thesis. University of Wyoming.

Cui, M. 1991. The ecophysiology of seedling establishment in subalpine conifers of the Central Rocky Mountains, USA. PhD Dissertation. University of Wyoming.

Cui, M.; Smith, W.K. 1990. Photosynthesis and water relations of young seedlings of *Abies lasiocarpa* with high natural mortality. Tree Physiology 8: 37-46.

---. 1991. Seedling microenvironment, gas exchange and survival during first year establishment in subalpine conifers. Tree Physiology 10: 44-53.

Knapp, A. K.; Smith, W.K. 1982. Factors influencing understory seedling establishment of Engelmann spruce and subalpine fir in southeast Wyoming. Canadian Journal of Botany 60: 2753-2761.

Noble, D.E. 1974. Natural regeneration of Engelmann spruce in clearcut openings on the Central Rockies as affected by weather, aspect, seedbed and biotic factors (Fraser Experimental Forest). PhD Dissertation. Colorado State University.

Noble, D.L.; Alexander, R.R. 1977. Environmental Factors affecting natural regeneration of Engelmann Spruce in the Central Rocky Mountains. Forest Science 23(4): 420-429.

Stahelin, R. 1943. Factors influencing the natural re-stocking of high altitude burns by coniferous trees in the Rocky Mountains. Ecology 24: 19-30.

Wright, K.V. 1963. Growth initiation in three species of conifers. Master's Thesis. University of Wyoming.

TREE DISEASES

INSECTS

Beal, J.A. 1943. Relation between tree growth and outbreaks of the Black Hills beetle. Journal of Forestry 41: 359-366.

McKnight, M.E. 1953. Unpublished reports of insect surveys on the Medicine Bow National Forest- Fort Collins Insect Laboratory 1935-1953. U.S. Forest Service Unpublished Reports RMFRES Library, Forest Collins, CO.

DWARF MISTLETOE

Hawksworth, F.G. 1955. Lodgepole pine dwarf mistletoe survey: Roosevelt and Medicine Bow National Forests: Progress report on 1953-54 surveys (Unpublished). USDA Forest Service Unpublished report RMFRES Library, Fort Collins, CO.

---. 1958. Survey of lodgepole pine dwarf mistletoe on the Roosevelt, Medicine Bow, and Bighorn National Forests. USDA, Station Paper No. 35, Fort Collins, CO.

Johnson, D.W.; Hawksworth, F.G.; Drummond, D.B. 1978. 1977 dwarfmistletoe loss assessment survey, Medicine Bow National Forest, Wyoming. USDA Forest Service Forest Insect and Disease Management, Methods Application Group Report 78-1.

COMANDRA BLISTER RUST

Geils, B.W.; Jacobi, W.R. 1987. Comandra blister rust: A threat to lodgepole pine. IN: Management of subalpine forests: Building on 50 years of research, Silver Creek, CO, 6 July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM 149.

---. 1989. Rating a lodgepole pine forest for potential losses to comandra blister rust. Proceedings 3rd IUFRO Rusts of pine working party conference, Banff Alberta, 18 September 1989. For. Can, Northwest Reg., North. For. Cent., Edmonton, Alberta Information Report NOR-X-317.

Jacobi, W. R.; Geils, B.W.; Taylor, J.E.; Zentz, W.R. 1993. Predicting the incidence of comandra blister rust on lodgepole pine: site, stand and alternate-host influences. Phytopathology 83(6): 630-637.

MISCELLANEOUS TREE DISEASE STUDIES

Fudge, C.W. 1988. Report on disease conditions - Hayden Ranger District. USDA USFS Region 2, Denver, CO.

Hatfield, W.C. 1943. Shoot blight of aspen and poplar caused by species of *Fusicladium*. Master's Thesis. University of Wyoming.

Johnson, D.W. 1995. Ecology and management of forest diseases and insects on the Medicine Bow National Forest. Draft white paper - Regional Office Region 2 USFS. Forest Insect and Disease Methods Application Group. Lakewood, CO

Lundquist, J.E.; Lister, C.K. 1991. Forest pest conditions in the Rocky Mountain region. USDA Forest Service Rocky Mountain Region, Denver, CO.

Mason, M.L. 1978. Biology of the aspen leaf beetle, *Gonioctus americana* (Schaffer), in the Medicine Bow National Forest, Wyoming. PhD Dissertation. University of Wyoming.

Ross, W.D. 1975. Host responses to decay columns containing *Gonoderma applanatum*, a *Coprinus sp. or Fomes igniarius*. Proceedings of the American Phytopathological Society 2:46,(Abstr., 102, Series SA660).

Ross, W.D. 1976. Fungi associated with root diseases of aspen in Wyoming. Canadian Journal of Botany 54: 10 pages

Ross, W.D. 1976. Relation of aspen root size to infection by *Gonoderma applantum*. Canadian Journal of Botany 54: 5 pgs

FOREST SUCCESSION

Akashi, Y.; Knight, D.H. 1986. The first nine years of forest succession after the Cinnabar Park fire. Unpublished Manuscript Dept. of Botany Univ. of Wyoming.

Bates, C.G. 1917. Forest succession in the Central Rocky Mountains. Journal of Forestry 15: 587-592.

Knapp, A.K. 1981. Ecophysiology and succession of three alpine conifers in southeast Wyoming. Master's Thesis. University of Wyoming.

Knapp, A.K.; Smith, W.K. 1981. Water relations and succession in subalpine conifers in southeastern Wyoming. Botanical Gazette 142: 502-511.

Raphael, M.G.; Marquart, S.L; Barrett, R.H. 1992. Evaluating stand conditions to support integrated silvicultural prescriptions for timber and wildlife: Snags and old growth. Habitat Futures, 1989: A Second Habitat Futures Workshop, Nybergm J.B., and W. B. Kessler, Pack Experimental Forest, Eatonville, WA, 16 October 1989. Victoria, Canada: Crown Publications.

Ronco, F. 1970. Engelmann spruce seed dispersal and seedling establishment in clearcut forest openings in Colorado. USFS Research Note RM-168, Fort Collins, CO.

TIMBER HARVEST AND WATER YIELD

Bevenger, G.S.; Troendle, C.A. 1987. The Coon Creek wildlife project; effects of water yield augmentation on wildlife. USDA Forest Service General Technical Report 149,

Brown, G.R. 1994. Annual Report for the Coon Creek Wildlife Project. USDA Forest Service Unpublished Report RMFRES, Laramie, WY.

Darrach, A.G., Jr.; Rockey, E.R. 1967. The first approximation of the Hydrologic analysis for the Encampment River Barometer Watershed. Unpublished Report. Medicine Bow National Forest. Laramie, WY.

Dunford, E.G.; Niederhof, C.H. 1944. Influence of aspen, young lodgepole pine and open grassland types upon factors affecting water yield (Fraser Experimental Forest). Journal of Forestry 42: 673-677.

Fletcher, J.J.; Rechard. P.A. 1976. Water loss from snowdrifts under oasis conditions. Water Resources Series No. 63 University of Wyoming Water Resources Research Institute, Laramie, WY.

Gary, H.L. 1980. Patch clearcuts to manage snow in lodgepole pine. Symposium I, 335-346. Boise, ID, 21 July 1980. Irrigation and Drainage Division, American Society of Civil Engineers.

---. 1974. Snow accumulation and snowmelt as influenced by a small clearing in a lodgepole pine forest. Water Resources Research 10 (2): 348-353.

---. 1979. Snow accumulation after harvesting in lodgepole pine in Wyoming and Colorado. USDA Forest Service Research Note RM- 366, Fort Collins, CO.

Gary, H.L.; Troendle, C.A. 1982. Snow accumulation and melt under various stand densities in lodgepole pine in Wyoming and Colorado. USDA Forest Service Research Note RM-417, Fort Collins, CO.

Knight, D.H.; Thilenius, J. 1975. Vegetation ecology. IN: The Medicine Bow Ecology Project, D. H. Knight, 37-59. Laramie, WY: University of Wyoming.

Knight, D.H.; Weaver, S.W.; Starr, C.R; Romme, W.H. 1979. Differential response of subalpine meadow vegetation to snow augmentation. Journal of Range Management 32 (4): 356-359.

Marrs, R.W. 1985. Prediction of runoff patterns in Wyoming using Landsat imagery to measure snowcover and estimate runoff from snowmelt. USGS Research Project Technical Completion Report USGS G-943 Project 5.

Niederhof, C.H.; Dunford, E.G. 1942. The effect of openings in a young lodgepole pine forest on the storage and melting of snow (Fraser Expt. Forest). Journal of Forestry 40 (10): 802-804.

Oberholtzer, M. 1976. Addendum to Encampment River barometer stream study, pre-logging phase (Project 0571-07-6901). Wyoming Game and Fish Department Administrative Report - 5075-07-6901, Cheyenne, WY.

---. 1972. Encampment River barometer stream study pre-logging phase. Wyoming Game and Fish Department Adminstrative Report - 0571-07-6901, Cheyenne, WY.

Raphael, M.G. 1987. The Coon Creek Wildlife Project: Effects of water yield augmentation on wildlife. USDA Forest Service General Technical Report RM 149, Fort Collins, CO.

Sommerfield, R.A.; Musselman, R.C.; Wooldridge, G.L.; Conrad, M.A. 1991. The performance of a simple degree-day estimate of snow accumulation to an alpine watershed. Snow, hydrology, and forests in high alpine areas (Proceedings of the Vienna Symposium), 221-228. August 1991.

Troendle, C.A.; Kaufmann, M.R. 1987. Influence of forests on the hydrology of the subalpine forest. Management of subalpine forests: Building of 50 years of research, SIlver Creek, CO, 6 July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM-149.

Wilm, H.G.; Dunford, E.G. 1948. Effect of timber cutting on water available for streamflow from a lodgepole pine forest. USDA Technical Bulletin #968, Washington, D.C.

TREE PHYSIOLOGY

Carter, G.A. 1985. Ecophysiology of *Picea engelmannii*, *Abies lasiocarpa* and *Pinus contorta* in the Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Wyoming.

Carter, G.A.; Smith, W.K. 1985. Influence of shoot structure on light interception and photosynthesis in conifers. Plant Physiology 79: 1038-1042.

---. 1987. Microhabitat comparisons of transpiration and photosynthesis in three subalpine conifers. Canadian Journal of Botany 66: 963-969.

Carter, G.A.; Smith, W.K.; Hadley, J.L. 1988. Stomatal conductance in three conifer species at different elevations during summer in Wyoming. Canadian Journal of Forest Research 18 (242-246).

Day, T.A.; DeLucia, E.H.; Smith, W.K. 1990. Effect of soil temperature on stem sap flow, shoot gas exchange and water potential in *Picea engelmannii* during snowmelt; effect of soil temperature. Oecologia 87: 474-481.

---. 1989. Influence of cold soil and snow cover on photosynthesis and conductance in two Rocky Mountain conifers. Oecologia 80: 546-552.

DeLucia, E.H. 1986. Effect of low root temperature in net photosynthesis, stomatal conductanve and carbohydrate concentration in Engelmann spruce (*Picea engelmannii* Parry) seedlings. Tree Physiology 2: 143-154.

---. 1987. The effects of freezing nights on photosynthesis, stomatal conductance and internal CO2 concentration in seedlings of Engelmann spruce (*Picea engelmannii* Parry). Plant, Cell and Environment 10: 333-338.

Delucia, E.H. 1986. Environmental limitations on the photosynthetic capacity in *Picea engelmannii* along an elevational gradient in southeastern Wyoming. PhD Dissertation. University of Wyoming.

DeLucia, E.H.; Smith, W.K. 1987. Air and soil temperature limitations on photosynthesis in Engelmann spruce during summer. *Canadian Journal of Forest Research* 17: 527-533.

Fahey, T.J. 1979. The effect of night frost on the transpiration of *Pinus contorta* ssp *latifolia*. Oecologia Plantarum 14: 483-490.

Fahey, T.J.; Young, D.R. 1984. Soil and xylem water potential and soil water content in contrasting *Pinus contorta* ecosystems, southeastern Wyoming. Oecologia 61: 346-351.

Fetcher, N. 1973. Leaf resistance of lodgepole pine in Wyoming. Master's Thesis. University of Wyoming.

---. 1976. Patterns of leaf resistance to lodgepole pine transpiration in Wyoming. Ecology 57 (2): 339-345.

Foster, J.R.; Smith, W.K. 1986. Influence of stomatal distribution on transpiration in low-wind environments. Plant, Cell and Environment 9: 751-759.

---. 1991. Stomatal conductance patterns and environment in high elevation phreatophytes of Wyoming. Canadian Journal of Botany 69: 647-655.

Hadley, J.L.; Smith, W.K. 1994. Effect of elevation and foliar age on maximum leaf resistance to water vapor diffusion in conifers of the Central Rocky Mountains, USA. Air pollutants and the leaf cuticle, K.E. Pearcy, Springer-Verlag NATO ASI Series Vol G36:261-268:

---. 1983. Influence of wind exposure on needle dessication and mortality for timberline conifers in Wyoming, U.S.A. Arctic and Alpine Research 15: 127-135.

---. 1990. Influence of leaf surface wax and leaf area-to-water content ratio on cuticular transpiration in conifers. Canadian Journal of Forestry Research 20: 1306-1311.

Haemmerle, H. 1987. Conifer leaf area in relation to stand age and site quality in the Medicine Bow Mountains, Wyoming. Master's Thesis. University of Wyoming.

Hansen, H.P. 1938. Ring growth and reproduction cycle in *Picea engelmannii* near timberline. University of Wyoming Publications in Botany 5: 1-9.

---. 1940. Ring growth and dominance in a spruce-fir association in southern Wyoming. American Midland Naturalist 23: 442-227.

Hemmerlein, M.T.; Smith, W.K. 1994. Structural scaling of light interception efficiency in *Picea engelmannii* and *Abies lasiocarpa*. Tree Physiology 14: 1139-1148.

Lindsay, J.H. 1971. Annual cycle of leaf water potential in *Picea engelmanii* and *Abies lasiocarpa* at timberline in Wyoming. Journal of Arctic and Alpine Research 3: 131-138.

---. 1967. The effect of environmental factors on the leaf water balance of conifers. Master's Thesis. University of Wyoming.

Lindsey, J.H. 1971. Annual cycle of leaf water potential in *Picea engelmanii* and *Abies lasiocarpa* at timberline in Wyoming. Arctic and Alpine Research 3: 131-138.

McNaughton, G.M. 1984. Comparative water relations of *Pinus flexilis* at high and low elevations in the Central Rocky Mountain Region. Master's Thesis. University of Wyoming.

Running, S.W. 1980. Environmental and physiological control of water flux through *Pinus contorta*. Canadian Journal of Forest Research 10: 82-91.

---. 1980. Relating plant capacitance of the water relations of *Pinus contorta*. Forest Ecology and Management 2: 237-252.

Schoettle, A.W. 1990. Importance of shoot structure to sunlight interception and photosynthetic carbon gain in *Pinus contorta* crowns. PhD Dissertation. University of Wyoming.

Smith, W.K. 1984. Environmental limitations on leaf conductance in Central Rocky Mountain conifers. IN: Establishment and tending of subalpine forests, H. Tutner, and W. Tranquillini (eds.), 95- 101. Eidg. Anst. Forstl. Versuchwes Rev. 270.

---. 1980. Importance of aerodynamic resistance on transpiration and photosynthesis in three conifers. Plant Physiology 65: 132- 135.

---. 1980. Importance of aerodynamic resistance to water use efficiency in three conifers under field conditions. Plant Physiology 65: 132-135.

Smith, W.K.; Carter, G.A. 1988. Shoot structural effects of needle temperature and photosynthesis in conifers. American Journal of Botany 75: 496-500.

Smith, W. K.; Schoettle, A.W.; Cui, M. 1991. Importance of leaf area measurement to the interpretation of gas exchange parameters of complex shoots (e.g. conifers). Tree Physiology 8: (121-127):

Smith, W.K.; Young, D.R; Carter, G.A.; Hadley, J.L.; McNaughton, G.M. 1984. Autumn stomatal closure in six conifer species of the central Rocky Mountains. Oecologia 63: 237-243.

Stone, J.E. 1969. Leaf water potential of *Pinus contorta* seedlings in relation to growth and seasonal moisture conditions. Master's Thesis. University of Wyoming.

FOREST PROCESSES

NUTRIENT CYCLING

Allen, M.F. 1977. Decomposition of six litter types under laboratory conditions: a study of rates and decomposing organisms. Master's Thesis. University of Wyoming.

Fahey, T.J. 1977. Changes in snow water nutrient content during outflow from coniferous forests and a clearcut. Master's Thesis. University of Wyoming.

---. 1979. Changes in nutrient content of snow water during outflow from Rocky Mountain coniferous forest. Oikos 32: 422-428.

---. 1982. Nutrient dynamics of aboveground detritus in lodgepole pine (*Pinus contorta* ssp. *latifolia*) ecosystems, southeastern Wyoming. Ecological Monographs 53: 51-72.

---. 1979. Water and nutrient cycling in lodgepole pine forests. PhD Dissertation. University of Wyoming.

Fahey, T.J.; Knight, D.H. 1986. Lodgepole pine ecosystems: biotic processes play a critical role in regulation material flux in Rocky Mountain lodgepole pine forests. Bioscience 36 (9): 610-617.

Fahey, T.J.; Yavitt, J.B; Blum, A.E.; Drever, J.I. 1985. Controls of soil solution chemistry in lodgepole pine forest ecosystems. Planetary Ecology. Editors D. E. Caldwell, J. A. Brierley, and C. L. Brierley, 473-484. New York: Van Nostrand Reinhold.

Fahey, T.J.; Yavitt, J.B.; Pearson, J.A.; Knight, D.H. 1985. The nitrogen cycle in lodgepole pine forests, southeastern Wyoming. Biogeochemistry 1: 257-275.

Knight, D.H.; Running, S.W.; Fahey, T.J. 1985. Water and nutrient outflow from contrasting lodgepole pine forests in Wyoming. Ecological Monographs 55(1): 29-48.

Knight, D.H.; Yavitt, J.B.; Joyce, G.D. 1991. Water and nitrogen outflow from lodgepole pine forest after two levels of tree mortality. Forest Ecology and Management 46: 215-225.

Miller, S.L.; Parsons, W.J.F.; McClean, T.M.; Knight, D.H. 1990. Nitrogen conservation in cut and uncut lodgepole pine trees linked via ectomycorrhizal fungi hyphae. 8th North American Conference on Mycorrhizae, page 209. Jackson, WY.

Parsons, W.F.J. 1992. Root gap dynamics and nitrogen transformations in a Rocky Mountain coniferous forest. Master's Thesis. University of Wyoming.

Parsons, W.F.; Knight, D.H.; Miller, S.L. 1994. Root gap dynamics in a lodgepole pine forest: nitrogen transformations in gaps of different size. Ecological Applications 4: 354-362.

Pearson, J. A.; Knight, D.H.; Fahey, T.J. 1987. Biomass and nutrient accumulation during stand development in Wyoming lodgepole pine forests. Ecology 68(6): 1966-1973.

---. 1987. Net ecosystem production and nutrient accumulation during stand development in Wyoming lodgepole pine forests. Ecology 68: 1966-1973.

Reid, C.P.P.; Odegard, G.J.; Hokenstrom, J.C.; McConnell, W.J.; Frayer, W.E. 1974. Effects of clearcutting on nutrient cycling in lodgepole pine forests Final Report USFS Research Grant 16-256-GR and 16-324-GR. Colorado State University, Fort Collins, CO.

Stump, L.M. 1991. Relationships between litter quality and nitrogen availablity in Rocky Mountain Forests (Fraser Experimental Forest: A-R: Routt NF). Master's Thesis. Colorado State University.

Yavitt, J.B. 1984. Nitrogen in lodgepole pine forests in relation to decomposition and soil solution chemistry. PhD Dissertation. University of Wyoming.

Yavitt, J.B.; Fahey, T.J. 1985. Chemical composition of interstitial water in decaying lodgepole pine bole wood. Canadian Journal of Forest Research 15(6): 1149-1153.

---. 1983. An experimental analysis of solution chemistry in a lodgepole pine forest floor. Oikos 43: 222-234.

---. 1986. Litter decay and leaching from the forest floor in *Pinus contorta* (lodgepole pine) ecosystems. Journal of Ecology 74: 525-545.

---. 1982. Loss of mass and nutrient changes of decaying woody roots in lodgepole pine forests, southeastern Wyoming. Canadian Journal of Forest Research 12(4): 745-752.

OTHER STAND LEVEL FOREST PROCESSES

Fahey, T.J.; Yavitt, J.B; Joyce, H. 1988. Precipitation and throughfall chemistry in *Pinus contorta* ssp. *latifolia* ecosystems, southeastern Wyoming. Canadian Journal of Forest Research 18: 337-345.

Knight, D.H.; Fahey, T.J.; Running, S.W.; Harrison, A.T.; Wallace. L.L. 1981. Transpiration from a 90-yr-old lodgepole pine forests estimated with whole-tree potometers. Ecology 62(3): 717-726.

Knight, D H.; Rogers, B.S.; Kyte, C.R. 1977. Understory plant growth in relation to snow duration in a Wyoming subalpine forest. Bulletin of the Torrey Botanical Club October: 314-319.

Nyberg, R.C.; Fahey,T.J. 1988. Soil hydrology in lodgepole pine ecosystems in southeastern Wyoming. Soil Science Society of America Journal 52: 844-849.

Parsons, W.F.; Miller, S.L.; Knight, D.H. 1994. Root gap dynamics in a lodgepole pine forest: ectomycorrhizal and non-mycorrhizal fine root activity after experimental gap formation. Canadian Journal of Forest Research 24: 1531-1538.

Reynolds, J.F.; Knight, D.H. 1973. The magnitude of snowmelt and rainfall interception by litter in lodgepole pine and spruce-fir forests in Wyoming. Northwest Science 47 (1): 50- 60.

Reynolds, R.W. 1971. Moisture interception by lodgepole pine and spruce-fir litter in southeastern Wyoming. Master's Thesis. University of Wyoming.

Schreiner, T.A. 1987. Characterization of root biomass and soil moisture in a riparian zones of southeastern Wyoming. Master's Thesis. University of Wyoming.

FIRE

Alexander, M. 1975. A preliminary reference list on the significance of fire in the forest communities of the Colorado Rockies. Unpublished manuscript, Graduate Research, Fire Science Program, Dept. of Forest and Wood Science Colorado State University (RMFRES Library, Fort Collins, CO).

Honaker, J.J. 1995. Fire history of the southern Sierra Madre Mountains, Wyoming, USA. Master's Thesis. University of Wyoming.

Orde, C.J. 1990. Fire History and Philosophy: Internal Report prepared for the Forest Supervisor. USDA Forest Service Medicine Bow National Forest Laramie, WY 1900/500.

Romme, W.H. 1977. Vegetation in relation to elevation, topography, and fire history in a Wyoming montane watershed. Master's Thesis. University of Wyoming.

Romme, W.H.; Knight, D.H. 1981. Fire frequency and subalpine forest succession along a topographic gradient in Wyoming. Ecology 62(2): 319-326.

Roppe, J.A. 1974. Effects on wildlife of a fire in a lodgepole pine forest. (Northern Colorado) Master's Thesis. Colorado State University.

Roppe, J.A.; Hein, D. 1978. Effects of fire on wildlife in a lodgepole pine forest. The Southwestern Naturalist 23(2): 279-288.

Strube, B.E. 1962. A study of the kinds of numbers of small rodents within a burned-over area of the Medicine Bow National Forest, Albany County Wyoming. Master's Thesis. University of Wyoming.

MOUNTAIN GRASSLANDS

Costello, D.F. 1940. Important species of the major forage types in Colorado and Wyoming. Ecological Monographs 14: 107-134.

Currie, P.O. 1975. Grazing management of ponderosa pine- bunchgrass ranges of the Central Rocky Mountains: The status of our knowledge. USDA Forest Service Research Paper RM-159, Fort Collins, CO.

Hepworth, K.W. 1989. Cattle grazing behavior on a foothill elk winter range and grazing systems and cattle behavior in southeastern Wyoming. Master's Thesis. University of Wyoming.

Nehring, M.E. 1952. Chemical analyses of five wildlife forage plants from the Sheep Mountain Federal Game Refuge area, Albany County, Wyoming. Master's Thesis. University of Wyoming.

Turner, G.T.; Paulsen, H.A. Jr. 1976. Management of mountain grasslands in the Central Rockies: The status of our knowledge. USDA Forest Service RM-161, Fort Collins, CO.

MAMMALS (Not TES Species)

Brown, L.N. 1967. Ecological distribution of mice in the Medicine Bow Mountains of Wyoming. Ecology 48: 677-680.

Grogan, R. 1995. Black bear ecology in Southeastern Wyoming. In Progress. Wildlife Cooperative Unit and Dept. of Zoology. Master's Thesis. University of Wyoming. Laramie, WY.

Jenniges, J.J. 1991. Habitat utilization of birds and small mammals in the North Fork of the Little Snake River drainage. Master's Thesis. University of Wyoming.

Lawrence, I.E. 1955. An ecological study of the snowshoe hare, *Lepus americanus* bairdii, Hayden, in the Medicine Bow National Forest of Wyoming. Master's Thesis. University of Wyoming.

Nordyke, K.A. 1988. An evaluation of small mammals as ecological indicators of old-growth conditions in the Medicine Bow National Forest of southeastern Wyoming. Master's Thesis. University of Wyoming.

Nordyke, K.A.; Buskirk, S.W. 1988. Evaluation of small mammals as ecological indicators of old growth conditions. IN: Management of amphibians, reptiles and small mammals in North America, 353-358. Flagstaff Arizona, 19 July 1988. Fort Collins, CO: USDA Forest Service General Technical Report RM-166.

Nordyke, K.A.; Buskirk, S.W. 1991. Southern red-backed vole, *Clethrionomys gapperi*, populations in relation to stand succession and old growth character in the Central Rocky Mountains. Canadian Field Naturalist 105: 330-334.

Pritchett, C.L. 1978. Variability in populations of the pocket gopher (*Thomomys talpoides rostralis*) along an altitudinal transect across the Medicine Bow Mountains, Wyoming. PhD Dissertation. University of Wyoming.

Raphael, M.G. 1987. Habitat associations of small mammals in a subalpine forest, southeastern Wyoming. IN: Proceedings: Management of amphibians, reptiles, and small Mammals in North America, 359-367. Flagstaff, AZ, 19 July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM-166.

Rothwell, R. 1977. The effects of forest type and mast crop on winter territories and populations of red squirrels (*Tamiasciurus hudsonicus baileyi*) in the Laramie Range of southeastern Wyoming. Master's Thesis. University of Wyoming.

Schulz, T.T.; Leininger, W.C. 1991. Nongame wildlife communities in grazed and ungrazed montaine riparain sites (Northern Colorado). Great Basin Naturalist 51 (3): 286-292.

Skryja, D.D. 1970. Some aspects of the ecology of the least chipmunk (*Eutamias minimus operarius*) in the Laramie Mountains of southeastern Wyoming. Master's Thesis. University of Wyoming.

Strickland, D., Shriver, J.; Finch, D. 1992. Small mammal faunas in aspen and conifer forests: The effects of macro- and micro- habitat variation Final Report RM-4201.2. University of Wyoming Department of Statistics.

AMERICAN MARTEN (Region 2 sensitive species)

Bennett, L.A. 1984. Marten ecology and habitat management in the Central Rocky Mountains PO contract 40-82LM-3-158. Colorado Cooperative Wildlife Research Unit, CSU, Fort Collins, CO.

Buskirk, S.W.; Forrest, S.C.; Raphael, M.G; Harlow, H.J. 1989. Winter resting site ecology of marten in the Central Rocky Mountains. Journal of Wildlife Management 53 (1): 191-196.

Buskirk, S.W.; Harlow, H.J. 1989. Body fat dynamics of the American marten (*Martes americana*) in winter. Journal of Mammalogy 70: 191-193.

Buskirk, S.W.; Harlow, H.J.; Forrest, S.C. 1987. Studies on the resting site ecology of marten in the Central Rocky Mountains. IN: Management of subalpine forests: Building on 50 years of research, Fort Collins, CO: USDA Forest Service General Technical Report RM-149.

Buskirk, S.W.; Harlow, H.L.; Forrest, S.C. 1988. Temperature regulation in American marten *Martes americana* in winter. National Geographic Research 4: 208-218.

Buskirk, S.W.; Harlow, H.J.; Forrest, S.C. 1987. Thermoregulatory behavior of American Marten Contract No. 28-C6-372 USFS and University of Wyoming. University of Wyoming Dept. of Zoology and Physiology.

Buskirk, S.W.; Lindstet, S.L. 1989. Sex biases in trapped samples of Mustelidae. Journal of Mammalogy 70: 88-97.

Buskirk, S.W.; McDonald, L.L. 1989. Analysis of variability in home range size of the American marten. Journal of Wildlife Management 53: 997-1004.

Campbell, T.M. 1979. Short-term effects of timber harvests on pine marten ecology. Master's Thesis. University of Wyoming.

Corn, J.G.; Raphael, M.G. 1992. Habitat characteristics at marten subniven access sites. Journal of Wildlife Management 56 (3): 442-448.

Henry, S.E.; Raphael, M.G; Ruggiero, L.F. 1990. Food caching and handling by marten. Great Basin Naturalist 50(4): 381-383.

Henry, S.E.; Raphael. M.G. 1989. Observations of copulation of free-ranging American marten. Northwestern Naturalist 70: 32- 33.

Henry, S.E.; Ruggiero, L.F. 1993. Den use and kit development of marten in Wyoming. XXI IUGB Congress Proceedings: In Press

Raphael, M.G. 21 April 1987. Preliminary suggestions for monitoring marten on the Medicine Bow National Forest. USFS Unpublished Report RMFRES, Laramie, WY.

Raphael, M.G.; Ruggiero, L.F.; Henry, S.E. 1991. Habitat selection by marten in the Sierra Madre Range, Wyoming. IN: Symposium on the Biology and Management of Martens and Fishers, Laramie, Wyoming, 29 May 1991.

Ruggiero, L.F. 1994. Microhabitat structures and forest characteristics associated with natal and maternal den sites of *Martes americana* in southern Wyoming. In review.

Ruggiero, L.F.; Aubry, K.B.; Buskirk, S.W.; Lyon, L.J.; Zielinski, W.J. 1994. The Scientific Basis for Conserving Forest Carnivores: American marten, fisher, lynx, and wolverine. USDA Forest Service General Technical Report RM-254, Fort Collins, CO.

Ruggiero, L. F.; Henry, S.E. 1993. Courtship and copulatory behavior of *Martes americana*. Northwestern Naturalist 74: 18-22.

Schulz, T.T.; Joyce, L.A. 1992. A spatial application of a marten habitat model. Wildlife Society Bulletin 20: 74-83.

Taylor, S.L.; Buskirk, S.W. In press (1995). Forest microenvironments and resting energetics of the American marten *Martes americana*. Ecography 17(3).

---. 1995. Subnivean microenvironments of montane coniferous forests. In preparation.

Wilbert, C.J. 1992. Spatial scale and seasonality of habitat selection by martens in southeastern Wyoming. Master's Thesis. University of Wyoming.

Wilbert, C.J.; Buskirk, S.W. 1995. Discontinuities of scale in habitat selection by American martens. In preparation.

BIRDS

GAME BIRDS (Not TES)

Coughlin, L. E. 1940. Sage Chickens - Studies on game birds. Unpublished report Medicine Bow National Forest, Laramie, WY.

Harju, H.J. 1974. An analysis of some aspects of the ecology of dusky grouse. PhD Dissertation. University of Wyoming.

Hengel, D.A. 1990. Habitat use, diet and reproduction of Merriam's turkeys near Laramie Peak, Wyoming. Master's Thesis. University of Wyoming.

BIRD SPECIES AND COMMUNITIES (Not TES)

Diem, K.L. 1980. Ponderosa pine bird communities. In: Management of western forests and grasslands for nongame birds, Salt Lake City, Utah, 11 February 1980. USDA Forest Service General Technical Report INT-86.

Finch, D.M. 1985. A weighted-means ordination of riparian birds in southeastern Wyoming. Riparian ecosystems and their management: Reconciling conflicting uses, U.S.Forest Service General Technical Report RM-120 495-497.

---. 1986. Similarities in riparian bird communities among elevational zones in southeastern Wyoming. IN: Proceedings Wyoming streamside zone conference, 105-110. Casper, WY, 28 April 1986. Laramie, WY: Wyoming Water Research Center, University of Wyoming.

___. 1987. Bird-habitat relationships in subalpine riparian sublands of the Central Rocky Mountains. IN: Management of subalpine forests: Building on 50 years of research, Silver Creek, CO, 6 July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM-149.

___. 1987. Bird-habitat relationships in riparian communities of southeastern Wyoming. PhD Dissertation. University of Wyoming

---. 1989. Habitat use and habitat overlap of riparian birds in three elevational zones. Ecology 70 (4): 866-880.

---. 1991. Positive associations among riparian bird species correspond to elevational changes in plant communities. Canadian Journal of Zoology 69: 951-963.

---. 1989. Species abundances, guild dominance patterns and community structure of breeding riparian birds. Freshwater Wetlands and Wildlife, 1989. Conference-8603101, DOE Symposium Series No. 61, Oak Ridge, Tenn: USDOE Office of Scientific and Technical Information.

Finch, D.M.; Reynolds, R.T. 1989. Bird response to understory variation and conifer succession in aspen forests. In: Issues and technology in the management of impacted wildlife, 87- 96. Boulder, CO: Thorne Ecological Institute.

Finch, D.M.; Ruggiero, L.F. 1993. Wildlife habitats and biological diversity in the Rocky Mountains and northern Great Plains. Natural Areas Journal 13: 191-203.

Finzel, J.E. 1962. Avian populations of four herbaceous communities at various elevations in southeastern Wyoming. PhD Thesis. University of Wyoming.

Gutzwiller, K.J. 1985. Riparian habitat use by breeding cavity- nesting birds in southeastern Wyoming. PhD Dissertation. University of Wyoming.

Gutzwiller, K.J.; Anderson, S.J. 1987. Multiscale associations between cavity-nesting birds and features of Wyoming streamside woodlands. Condor 89: 534-548.

Loose, S.H. 1993. Woodpecker habitat use in the forests of southeast Wyoming. Master's Thesis. University of Wyoming.

MacLaren, P.A. 1986. Resource partitioning in an assemblage of breeding raptors from southeastern Wyoming. Master's Thesis. University of Wyoming.

McCafferty, C.E. 1930. An annotated and distributional list of the birds of Wyoming. Master's Thesis. University of Wyoming.

McDonald, L.; Mullen, L.; Finch, D.. 1992. Analysis of data collected for avian community response to habitat variation and conifer succession in aspen forests. USDA Forest Service Final Report RM-4201.1, Fort Collins, CO.

---. 1992. Analysis of data collected for avian community response to habitat variation and conifer succession in aspen forests Final Report RM-4201.1 Cooperative agreement No. 28-C1- 563. U. Wyoming Department of Statistics.

Reid, R. 1979. A comparison of bird populations in plant communities of alpine and subalpine vegetation in the Rocky Mountains (Medicine Bow and Beartooth Mountains) and the Sierra Nevada of California. Duke University Senior Undergraduate Thesis.

Scott, V.E.; Whelan, J.A.; Svoboda, P.L. 1980. Cavity- nesting birds and forest management. In: Management of Western Forests and Grasslands for nongame Birds: Workshop Proceedings, 311-324. Salt Lake City, Utah, 11 February 1980. USDA Forest Service General Technical Report INT-86.

Suchey, W.J. 1984. A comparison of five survey techniques for birds in high altitude shrubsteppe. Master's Thesis. University of Wyoming.

Wachob, D.G. 1993. Nest and foraging site selection in the mountain chickadee (*Parus gambeli*): A microclimate analysis. Master's Thesis. University of Wyoming.

TES BIRDS

Enderson, J.H. 1964. A study of the prairie falcon (*Falco mexicanus* Schlegel) in the central Rocky Mountain Region. Auk 81: 332-357.

Harper, J. 1993. Sensitive Animal Species for the MBNF. In-house report for Sensitive Species lists, Laramie, WY.

Herren, V.A. 1994. Boreal owl mating habitat in Wyoming's Sierra Madres. Master's Thesis. University of Wyoming.

Linder, K.A. 1994. Habitat utilization and behavior of nesting Lewis' woodpeckers (*Melanerpes lewis*) in the Laramie Range, southeastern Wyoming. Master's Thesis. University of Wyoming.

Oedekoven, O.G. 1985. Columbian sharp-tailed grouse population distribution and habitat use in south central Wyoming. Master's Thesis. University of Wyoming.

Sisson, J.; Nolde, M.J. 1978. Goshawk - Ecoregion M3113. Unpublished Report - U.S. Fish and Wildlife Service, Ecological Services, Fort Collins, CO.

Squires, J.R.; Ruggiero, L.F. 1995a. Nest site preference of goshawks in south-central Wyoming. Submitted for publication. Rocky Mountain Forest and Range Experiment Station, Laramie, WY

Squires, J.R.; Ruggiero, L.F. 1995b. Winter movements of adult northern goshawks that nested in southeastern Wyoming. Raptor Research 29(1):(In press)

BIRDS AND EFFECTS OF TIMBER HARVEST OR LIVESTOCK GRAZING

Keller, M.E. 1987. The effect of forest fragmentation on birds in spruce-fir old-growth forests. PhD Dissertation. University of Wyoming.

Keller, M.E.; Anderson, S.H. 1992. Avian use of habitat configurations created by forest cutting in Southeastern Wyoming. The Condor 94: 55-65.

Krueger, H.D. 1985. Avian response to mountainous shrub-willow riparian systems in southeastern Wyoming. PhD Dissertation. University of Wyoming.

Krueger, H.O.; Anderson, S.H. 1985. The use of cattle as a management tool for wildlife in shrub-willow riparian systems. IN: Riparian ecosystems and their management: Reconciling conflicting uses, R. R. Johnson, C. D. Ziebell,

D. R. Patton, P. F. Ffolliott, and R. H. Hamre, 1-5. Tuscon, AZ, 16 April 1985. USDA Forest Service General Technical Report RM-120 Fort Collins, CO.

Scott, V E.; Crouch, G.L. 1988. Breeding birds and small mammals in pole-size lodgepole pine and small inclusions of aspen in Central Colorado. USDA Forest Service Research Note RM-482, Fort Collins, CO.

OTHER THREATENED, ENDANGERED, CANDIDATE OR SENSITIVE SPECIES

Mills, S.; Neighbors, M. 1995. Intensive data gathering project (fine-filter analysis) for occurrences of rare, threatenend, endangered and sensitive species in Sections M331H and M331I, North Central Highlands and Northern Parks and Ranges in Wyoming. Contract with Region 2 USFS. Wyoming Natural Diversity Database of THE Nature Conservancy Laramie, WY

BIG GAME

BIGHORN SHEEP

Adams, T. 1991. Sheep of Laramie Peak. Wyoming Wildlife 55 (12): 18-25.

Arnett, E.B. 1990. Bighorn sheep habitat selection patterns and response to fire and timber harvest in southcentral Wyoming. Master's Thesis. University of Wyoming.

Arnett, E.B.; Cook,J.G; Lindzey, F; Irwin, L. 1989. Encampment River bighorn sheep study - June, 1987 - Dec. 1988 summary. Dept. of Zoology and Physiology U. WY Laramie.

Bohne, J. 1984. Encampment River bighorn sheep - Job completion Report DIstrict V. Wyoming Game and Fish Dept. Cheyenne, WY.

Cook, J.G. 1990. Habitat, nutrition and population ecology of two transplanted bighorn sheep populations in southcentral Wyoming. PhD Thesis. University of Wyomng.

Cook, J.G.; Arnett, E.B; Irwin, L.L.; Lindzey, F. 1989. Ecology and population dynamics of transplanted bighorn sheep herds in southcentral Wyoming. Dept. of Zoology and Physiology, University of Wyoming.

Cook, J.G.; Arnett, E.B.; Irwin, L.L. Lindzey, F. 1990. Mountain sheep response to burning in southcentral Wyoming. Department of Zoology and Physiology, University of Wyoming.

Cook, J.G.; Hershey, T.J.; Irwin, L.L. 1994. Vegetative response to burning on Wyoming mountain shrub big game ranges. Journal of Range Management 47: 296-302.

Fitzsimmons, N.N.; Buskirk, S.W. 1995. Genetic changes in translocated populations of bighorn sheep. Submitted for publication.

Fitzsimmons, N. N.; Buskirk, S.W.; Smith. M.K. In press (1995). Population history, genetic variability and horn growth in bighorn sheep. Conservation Biology 9(1).

Haas, W.L. 1979. Ecology of an introduced herd of Rocky Mountain bighorn sheep in southcentral Wyoming. Master's Thesis. Colorado State University.

Haas, W.L.; Decker, E. 1980. A study of a recently introduced bighorn sheep herd. Proceedings Biennial Symposium Northern Wild Sheep and Goat Council 2: 143-166.

Hengel, D.A. 1990. Habitat use, diet, population dynamics, seasonal distribution, and movement patterns of the Laramie Peak bighorn sheep herd. Unpublished Report - Wyoming Cooperative Fishery and Wildlife Research Unit, University of Wyoming, Laramie, WY.

Irwin, L.L.; Cook, J.G. 1987. Platte River Bighorn Sheep Study. Unpublished Study - Dept of Zoology and Physiology Univ. WY., Laramie, WY.

Rounsaville, K. 1980. Analysis of the management situation, Sheep Mountain Wildlife Refuge. Unpublished Report for the Medicine Bow National Forest.

USDA Forest Service, Wyoming Game and Fish Department, and Bureau of Land Management. 1985. Memorandum of Agreement to transplant bighorn sheep to the Encampment River Canyon. Laramie, WY.

MULE DEER

Case, R.M. 1963. Range Analysis of deer use of bitterbrush on Pole Mountain Unit. Unpublished Report - Medicine Bow National Forest Administrative Study, Laramie, WY.

Compton, T.L. 1974. Some interspecific relationships among deer, elk, domestic livestock and man in the western Sierra Madre of southcentral Wyoming. PhD Thesis. University of Wyoming.

Compton, T.S. 1975. Mule Deer and elk relationship on western Sierra Madre area of south central Wyoming. Wildlife Technical Report No. 1, Wyoming Game and Fish Division, Cheyenne, WY.

Goodwin, G.A. 1973. Fecal analysis as a measure of forage utilization by mule deer in southeastern Wyoming. Master's Thesis. University of Wyoming.

---. 1975. Seasonal food habits of mule deer in southeastern Wyoming. USDA Forest Service Research Note RM-287, Fort Collins, CO.

Muchmore, D.C. 1969. An ecological study of mule deer on an all season range. Master's Thesis. University of Wyoming.

Regelin, W.L. 1971. Deer forage quality in relation to logging in the spruce fir and lodgepole pine type in Colorado. Master's Thesis. Colorado State University.

Regelin, W.L.; Wallmo, O.C. 1978. Duration of deer forage benefits after clearcut logging of subalpine forest in Colorado (Fraser Experimental Forest). USDA Forest Service Research Note - RM-356, Fort Collins, CO.

Spraker, T.H. 1973. An ecological study of the mule deer (*Odocoileus hemionus*) on Sheep Mountain, Albany County, Wyoming. Master's Thesis. University of Wyoming.

Strickland, D. 1975. Mule deer in the Medicine Bow Mountains - Ecology Study. Unpublished Report Wyoming Game and Fish Department FW-3-R-21, Laramie, WY.

Strickland, M.D. 1975. An investigation of the factors affecting the management of a migratory mule deer herd in Southeastern Wyoming - the Snowy Range. PhD. University of Wyoming.

Wallmo, O.C. 1969. Response of deer to alternate strip-cutting of lodgepole pine and spurce-fir timber in Colorado (Fraser Experimental Forest). USDA Forest Service Research Note RM-141, Fort Collins, CO.

Wallmo, O.C.; Regelin, W.L.; Reichert, D.W. 1972. Forage use by mule deer relative to logging in Colorado (Fraser Experimental Forest). Journal of Wildlife Management 36 (4):1025-1033.

Welch, A.J. 1968. Livestock grazing effects on all season mule deer ranges. Master's Thesis. University of Wyoming.

ELK

Guest, J.E. 1971. Carrying capacity of elk summer range. PhD Dissertation. University of Wyoming.

Hohl, R.J. 1977. Summer habitat preference and vegetation utilization of elk in the Snowy Range, Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Ward, A.L. 1973. Elk behavior in relation to multiple uses on the Medicine Bow National Forest. Unpublished Report - Rocky Mountain Forest and Range Experiment Station, Laramie, WY. also published in Proc. 53rd Ann. Conf. Western Association of State Game and Fish Commissioners Salt Lake City, UT July 11-13, 1973,

---. 1976. Elk behavior in relation to timber harvest operations and traffic on the Medicine Bow Range in south-central Wyoming. Elk-Logging-Roads symposium proceedings, 32-43. Moscow, Idaho, December 1976. Laramie, WY: USDA For. Serv.

---. 1980. Multiple use of timbered areas: Views of a wildlife manager specifically for elk and mule deer. Unpublished report - Rocky Mountain Forest and Range Experiment Station, Laramie, WY.

---. 1984. The response of elk and mule deer to firewood gathering on the Medicine Bow Range in southcentral Wyoming. IN: Proceedings of the 1984 western states and provinces elk workshop, 28-40. Edmonta, Alberta Canada, 17 April 1984.

---. 1982. Study of elk in the Little Snake River known recoverable coal resource areas of southcentral Wyoming Interim Report. Unpublished Report USDA Forest Service Cooperative Agreement with BLM (WY910-1A1-507) and Rocky Mountain Energy Company (RM-81-157-CA).

---. 1985. Study of elk in the Little Snake River Known Recoverable Coal Resource Area (KRCRA) of southcentral Wyoming. USDA Forest Service Final Report. Cooperative Agreement among USFS, BLM and Rocky Mountain Energy CO, Laramie, WY.

Ward, A.L.; Diem. K.; Weeks, K. 1975. The impact of snow on elk. IN: The Medicine Bow Ecology Project Final Report to the Office of Atmospheric Resources, U.S. Bureau of Reclamation Contract No 14-06-D-7198. U. of Wyoming, Laramie.

Ward, A.L.; Fornwalt, N.E.; Henry, S.E;; Hodorff, R.A. 1980. Effects of highway operation practices and facilties in elk, mule deer, and pronghorn antelope. Unpublished Report of Rocky Mountain Forest and Range Experiment Station, Laramie, WY.

MOOSE

Colescott, J.H. 1994. Winter forage selection and plant response: a dynamic relationship between shiras moose (*Alces alces shirasii*) and riparian willow (*Salix spp.*). Master's Thesis. University of Wyoming.

Nowlin, R.A. 1985. Distribution of moose during occupation of vacant habitat in northcentral Colorado (Routt NF). PhD Dissertation. Colorado State University. Fort Collins, CO.

Zimmerman, M.L. In progress (1995). A study of moose herbivory on willow communities in Colorado. Master's Thesis. Colorado State University, Fort Collins, CO.

BIG GAME HABITAT

Blunt, W.H. 1980. Wildlife Habitat and Successional Stages of Vegetation of Lodgepole Pine Forests. USDA Forest Service Specialist Report - Medicine Bow National Forest,

Butler, G.B. 1972. Ecological inventory and analysis of the Laramie Peak big game winter range. Master's Thesis. University of Wyoming.

Butler, G.B. 1973. Range Survey - Summary Report - Medicine Bow Unit. WY Game and Fish. Cheyenne, Wyoming.

Cartwright, L.T. 1975. Big game habitat analysis of a low altitude, immature lodgepole pine clearcut area on the Routt National Forest, Medicine Bow Mountain range. Master's Thesis. University of Wyoming.

Crouch, G.L. 1987. Big game habitat research in subalpine forests in the Central Rocky Mountains (Fraser Experimental Forest). IN:Management of subalpine forests: Building on 50 years of research, 106-112. Silver Creek, Colorado, 6 July 1987. Fort Collins, CO: USDA Forest Service General Technical Report RM- 149.

Current, F.B. 1985. Prediction of big game winter habitat. Unpublished report prepared for the Medicine Bow National Forest by University of Wyoming Department of Range Management and Wyoming Game and Fish Department, Laramie, WY.

Porter, K.A. 1959. Effects of subalpine timber cutting on wildlife in Colorado (Fraser Experimental Forest). Master's Thesis, Colorado State University.

Davis, P.R. 1977. Cervid response to forest fire and clearcutting in southeastern Wyoming. Journal of Wildlife Management 41 (1): 785-788.

---. 1976. Response of vertebrate fauna to forest fire and clearcutting in southcentral Wyoming. PhD Dissertation. University of Wyoming.

---. 1976. Response of vertebrate fauna to forest fire and clearcutting in south central Wyoming. Contract No 16-391-CA and 16-464-CA USDA Forest Service Unpublished report at RMFRES, Fort Collins, CO. Laramie, WY.

Gerhart, W.A. 1984. Range Trend Survey, Laramie Peak Wildlife Habitat Mangement Unit. WY Game and Fish. Cheyenne, Wyoming.

Gerhart, W.A. 1983. Shelterbelt establishment evaluations on the Pennock Mountain Unit. WY Game and Fish, Cheyenne, Wyoming.

Gerhart, W.A. 1983. Trends in Range Condition on the Pennock Mountain Unit. WY Game and Fish, Cheyenne, Wyoming.

Guest, J.E. 1973. Range Survey - Summary Report - Pennock Mountain. WY Game and Fish, Cheyenne, Wyoming.

May, M. 1958. Bibliography on deer-range relationships. University of Wyoming, Laramie Wyoming Wyoming Range Management Issue 115: 5.

WY Game and Fish. 1972. Federal Aid in Fish and Wildlife Restoration Project Statement, Amendment No. 26. WY Game and Fish, Cheyenne, Wyoming.

WY Game and Fish. 1984. Annual Report, Pennock Mountain Wildlife Management Unit, FY84. WY Game and Fish. Cheyenne, Wyoming.

WY Game and Fish. 1984. Annual Report, Laramie Peak Wildlife Habitat Mangement Unit. WY Game and Fish. Cheyenne, Wyoming.

WY Game and Fish. 1981. Comprehensive Mangement Plan for the Laramie Peak Wildlife Habitat Mangement Unit. WY Game and Fish, Cheyenne, Wyoming.

WY Game and Fish. 1981. Medicine Bow Unit Wildlife Habitat Management Plan. WY Game and Fish, Cheyenne, Wyoming.

RIPARIAN AND AQUATIC ECOSYSTEM STUDIES

BEAVERS

Call, M.W. 1960. A study of the Pole Mountain beaver and their relation to the brook trout fishery. Master's thesis. University of Wyoming.

---. 1966. Beaver pond ecology and beaver-trout relationships in southeastern Wyoming. Wyoming Game and Fish Administrative Report FW-14-R, Cheyenne, WY.

---. 1970. Beaver pond ecology and beaver-trout relationships in southeastern Wyoming. PhD Dissertation. University of Wyoming.

Osborn, D. 1949. A study of age classes, reproduction and sex ratios of beaver in Wyoming. Master's Thesis. University of Wyoming.

Osmundson, C.L. 1990. Dynamics of beaver food caches and cache size as a predictor of colony size in Wyoming. Master's Thesis. University of Wyoming.

Osmundson, C.L.; Buskirk, S.W. 1993. Size of food caches as a predictor of beaver colony size. Wildlife Society Bulletin 21: 64-69.

Skinner, Q.D.; Speck, J.E. Jr.; Smith, M; Adams, J.C. 1984. Stream water quality as influenced by beaver within grazing systems in Wyoming. Journal of Range Management 37 (2): 142-146.

Snigg, M. 1986. Pole Mountain beaver pond re-inventory. Wyoming Game and Fish Department Administrative Report - 5085-13-7301, Cheyenne, WY.

Williges, W.A. 1946. A beaver survey on the Pole Mountain division of the Medicine Bow National Forest. Master's thesis. University of Wyoming.

Winkle, P.L. 1988. Relations between brook trout abundance and habitat features in beaver ponds in southeastern Wyoming. Master's Thesis. University of Wyoming.

RIPARIAN ECOSYSTEMS

Gierisch, R.K. 1964. Effects of three systems of cattle grazing on willow sprouts in mountain meadows (Pole Mtn. Medicine Bow NF). Unpublished report Region 2 USFS RMFRES files, Denver, CO.

Goyne, L. 1994. Battle Creek riparian demonstration project (In progress- 1994). Laramie, WY, U. WY. Range Management and Water Resources (T.A. Wesche and Q.D.Skinner - PI).

Henszey, R.J. et al. 1991. Response of montane meadow vegetation after two years of streamflow augmentation. Regulated Rivers: Research and Management 6: 29-38.

Henszey, R.J. 1993. Sedge, hairgrass, and reedgrass response after two years of streamflow augmentation. PhD Dissertation. University of Wyoming. Laramie, WY.

Young, M.K. 1991. A fish out of water: The relations between riparian zones and stream channels. Annals of the Association of Colorado/Wyoming Chapter of the American Fisheries Society.

AMPHIBIANS AND REPTILES

Bartlet, P.; Orde, C. 1987. Wood frog Mmnitoring. USDA Forest Service - Medicine Bow National Forest Internal Report, Laramie, Wyoming.

Baxter, G.T. 1946. A study of the amphibians and reptiles of Wyoming. Master's Thesis. University of Wyoming.

Cope, E.D. 1871. Report on the reptiles and fishes obtained by the naturalists of the expedition. IN: Second annual report, United States Geological Survey of Wyoming, and portions of contiguous territories.

Corn, P.; Stolzenberg, W.E.A. 1989. Acid precipitation studies in Colorado and Wyoming: interim report of surveys of montane amphibians and water chemistry. U.S. Fish and Wildlife Service Biological Report 80 (40.26).

Corn, P.S.; Vertucci, F.A. 1993. Descriptive risk assessment of the effects of acidic deposition on Rocky Mountain amphibians. Journal of Herpetology (In review).

Garber, C. 1994. A status survey for spotted frogs, wood frogs, and boreal toads in the Mountains of Southern and Eastern Wyoming. USDA Forest Service - Medicine Bow National Forest, Laramie, Wyoming.

Poltrone, R.T. 1987. Habitat quality evalution and a monitoring program for the northern leopard frog (*Rana pipiens*) in southeastern Wyoming. Master's Thesis. University of Wyoming.

INVERTEBRATES

Baxter, T. No date. A key to the common organisms occurring in Telephone Creek, Nash Fork Creek, North Fork Creek and the Little Laramie River, Wyoming. University of Wyoming, Laramie, WY.

Beetle, A.A. 1954. Molluscs of Albany County, WY. Nautilus 67(4):121-129.

Billings, S.M. 1960. Descripitive study and ecological analysis of the "splash" community of mosses and invertebrates bordering Nash Fork Creek, Medicine Bow Mountains, Wyoming. U. of Wy. Zool Dept.

Blake, I.H. 1945. An ecological reconnaissance in the Medicine Bow Mountains. Ecological Monographs 15: 207-242.

Bozek, M.A.; DeBrey, L.D; Lockwood, J.A. 1994. Diet overlap among size classes of Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) in a high-elevation mountain stream. Hydrobiologia 273:9-17.

Brown, C.M. 1939. The Oedogoniaceae of the Medicine Bow Mountains of Wyoming. Master's Thesis. University of Wyoming.

Creek, M. 1930. Nymphs of Plecoptera and Ephemerida of some streams of the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

DeBrey, L.D. 1989. The effect of sediment on the aquatic insects of the North Fork Little Snake River, PhD Dissertation. University of Wyoming.

DeBrey, L.D. 1993. Mercury content of fish tissue, sediment and water from Douglas Creek, Bobby Thompson Campground, Medicine Bow National Forest, Wyoming. Report for Jack Noblitt and Associates, Cheyenne, WY.

DeBrey, L.D. 1995. Effects of copper and sediment on the aquatic macroinvertebrates of Bear Creek. Report submitted to Lidstone and Anderson consulting company, Fort Collins, CO.

Debrey, L.D.; Lockwood, J.A. 1990. Effects of sediment and flow regime on the aquatic insects of a high mountain stream. (North Fork Little Snake River). Regulated Rivers: Research and Management 5: 241-250.

Good, W.R. 1974. Some effects of spring snowmelt runoff on aquatic invertebrate populations in a high mountain stream. PhD Dissertation. University of Wyoming.

Keith, R.M. 1987. Macroinvertebrate community information collected at sites within the control and treatment section of the Little Laramie River. Wyoming Game and Fish Department Administrative Survey -, Cheyenne, WY.

Loar, J.M. 1975. An analysis of the factors influencing the distribution of insects in two high mountain streams. PhD Thesis. University of Wyoming.

Magnum, F.A. 1988. Aquatic ecosystem inventory, macroinvertebrate analysis, Green Timber Creek, Medicine Bow National Forest. USDA Forest Service, Intermountain Region, Provo, Utah.

Pogge, A. 1962. A study of the classification and distribution of Plecoptera nymphs in Sally Creek, Nash Fork Creek and the Little Laramie River in Wyoming. Master's Thesis. University of Wyoming.

Raley, C.M. 1986. Availability and use of invertebrate food resources by high elevation riparian birds in southeastern Wyoming. Master's Thesis. University of Wyoming.

Reyes, M. 1994. Invertebrates as Indicators of Biotic Integrity in Montane Wetlands. Graduate proposal for Department of Zoology and Physiology. University of Wyoming. Laramie, Wyoming.

Rhodes, H A.; Hubert. W.A. 1991. Submerged undercut banks as macroinvertebrate habitat in a subalpine meadow stream. Hydrobiologia 213: 149-153.

Saunders, J.F.; Belk, I.D; Dufford. R. 1993. Persistence of *Brancinecta paludosa* (Anostraca) in Southern Wyoming, with notes on zoogeography. Journal of Crustacean Biology 13 (1): 184- 189.

Schmidt, P. 1990. Subnivean arthropod ecology in the Medicine Bow Mountains. Master's Thesis. University of Wyoming.

FISH

COLORADO CUTTHROUT TROUT

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6.

Behnke, R.J.; Zarn, M. 1976. Biology and management of threatened and endangered western trout. USDA Forest Service General Technical Report RM-28, Fort Collins, CO.

Bozek, M.A. 1990. Generality of habitat models for Colorado River cutthroat trout fry and the influence of adults on habitat choice and behavior. PhD Dissertation. University of Wyoming.

Bozek, M.A.; Rahel, F.J. 1991. Assessing habitat requirements of young Colorado River cutthroat trout by use of macrohabitat and microhabitat analyses. Transactions of the American Fisheries Society 120: 571-581.

Bozek, M.A.; Rahel, F.J. 1991. Comparison of streamside visual counts to electrofishing estimates of Colorado River cutthroat trout fry and adults. North American Journal of Fisheries Management 11: 38-42.

Bozek, M.A., Rahel, F.J. 1992. Generality of microhabitat suitability models for young Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) across sites and among years in Wyoming streams. Canadian Journal of Fisheries and Aquatic Sciences 49: 552-564.

Cheeney, D. 1987. Colorado River cutthroat spawning (8705SRC). Wyoming Game and Fish Department Administrative Report - 8705SRC, Cheyenne, WY.

Fausch, K.D.; Young, M.K. 1995. Evolutionarily significant units and movement of resident stream fishes: a cautionary tale. IN: Nielsen, J.L; Powers, D. (eds.) Evolution and the aquatic ecosystem: defining unique units in population conservation. American Fisheries Society Symposium 17. American Fisheries Society, Bethesda, Maryland.

Herger, L.G. 1993. Assessment of a basin-wide habitat inventory technique relative to the Colorado River Cutthroat trout. Master's Thesis. University of Wyoming.

Jacobson, W.; Condor, A. 1985. Colorado River cutthroat trout distribution survey of the Mill Creek/Nighthawk Timber Sale area, Carbon County, WY. Wyoming Game and Flsh Department Administrative Report - 5085-07-8001, Cheyenne, WY.

Jespersen, D. M. 1979. Instream flow determinations and impact evaluation of water diversions on the Colorado River cutthroat trout and brook trout in the North Fork drainage. Medicine Bow National Forest Specialist Report, Laramie, WY.

---. 1981. A study of the effects of water diversion on the Colorado River cutthroat trout (Salmo clarkii pleuriticus) in the drainage of the North Fork of the Little Snake River in Wyoming. Master's Thesis. University of Wyoming.

Jespersen, D.; Condor. A. 1986. Colorado River cutthroat trout spawning and incubation habitat summary. Wyoming Game and Fish Department Administrative Survey - IF-5085-13-6602, Cheyenne, WY.

Kanaly, J. 1973. Comprehensive management and enhancement plan for Colorado River cutthroat trout in Wyoming. Wyoming Game and Fish Department Administrative Report - 5073-01-5504, Cheyenne, WY.

Lakey, R.E. 1966. A study of cutthroat and brook trout populations in beaver ponds in southeastern Wyoming. Master's thesis. University of Wyoming.

---. 1966. A study of cutthroat and brook trout populations in beaver ponds in southeastern Wyoming. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.

Oberholtzer, M. 1987. A fisheries survey of the Little Snake River drainage, Carbon County, Wyoming. Wyoming Game and Fish Department, Cheyenne, Wyoming. Administrative Report. Project 5086-01-8501.

Oberholtzer, M. 1990. Current status of Colorado River cutthroat trout in the Little Snake River Enclave. Wyoming Game and Fish Department Administrative Report - 5090-28-8501, Cheyenne, WY.

Quinlan, R.E. 1980. A study of the biology of the Colorado River cutthroat trout (*Salmo clarkii pleuriticus*) population in the North Fork of the Little Snake River drainage in Wyoming. Master's Thesis. University of Wyoming.

---. 1980. A study of the biology of the Colorado River cutthroat trout (*Salmo clarkii pleurictus*) Population in the North Fork of the Little Snake River. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.

Speas, C.; Fowden, M.; Gorges, M.; Rinkis, T.; Eaglin, G.; Wengert, B. 1994. Conservation plan for Colorado River cutthroat trout (*Onchorhynchus clarkii pleuricitus*) for the Little Snake River drainage in southeastern Wyoming. Interagency Plan USDA Forest Service, USDI Bureau of Land Management and Wyoming Game and Fish Department. Medicine Bow National Forest, Laramie, WY

Stone, M.D. 1987. Comprehensive management and enhancement plan for Colorado River cutthroat trout in Wyoming (1987). Wyoming Game and Fish Department Administrative Report, Cheyenne, Wyoming.

Young, M.K. 1989. Effect of substrate composition on the survival to emergence of Colorado River cutthroat trout and brown trout. PhD Dissertation. University of Wyoming.

Young, M.K. 1995. Resident trout and movement: consequences of a new paradigm. FHR Currents 18. 5pp.

Young, M.K. (technical editor). 1995. Conservation assessment for inland cutthroat trout. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. General Technical Report RM-GTR-256.

Young, M.K.; Grost, R.T.; Hubert, W.A; Wesche, T.A. 1990. Methods for assessing the impacts of sediment deposition on the survival to emergence of Colorado River cutthroat trout and brown trout. U.S. Fish and Wildlife Service and University of Wyoming Dept of Range Management, Laramie, WY.

Young, M.K.; Hubert, W.A.; Wesche, T.A. 1991. Selection of measures of substrate composition to estimate survival to emergence of salmonids and to detect changes in stream substrates. North American Journal of Fisheries Management 11: 339-346.

FISH OTHER THAN COLORADO RIVER CUTTHROAT TROUT

Binns, N.A. 1977. Evaluation of trout habitat that would be impacted by Cheyenne's proposed Phase II water development in the North Fork Little Snake River Drainage. Wyoming Game and Fish Department Administrative Report - 5076-09-6002, Cheyenne, WY.

Bozek, M.A.; Hubert, W.A. 1992. Segregation of resident trout in streams as predicted by three habitat dimensions. Canadian Journal of Zoology 70: 886-890.

Chisholm, I. 1985. Winter stream conditions and brook trout habitat use on the Snowy Range, Wyoming. PhD Dissertation. University of Wyoming.

Chisholm, I.M.; Hubert, W.A. 1986. Influence of stream gradient on standing stock of brook trout in the Snowy Range, Wyoming. Northwest Science 60 (2): 137-139.

Christensen, D.J. 1965. A study of brook trout ecology: with emphasis on spawning behavior in the Medicine Bow Mountains of Wyoming. Master's Thesis. University of Wyoming.

---. 1965. A study of brook trout ecology with emphasis on spawning behavior part VII. Wyoming Game and Fish Department Adminstrative Report - Cooperative Research, Cheyenne, WY.

Condor, A.; McKnight, R. 1990. A fisheries survey of the Horseshoe Creek drainage, tributary to the North Platte River, Platte, Albany and Converse county. Wyoming Game and Fish Department Administrative Report - 5589-01-8901, Cheyenne, WY.

Eaglin, G.S.; Hubert, W.A. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 13: 844-846.

Eiserman, F. 1959. Report of fishing - Pole Mountain Division, Medicine Bow National Forest - 1959. Wyoming Game and Fish Department Administrative Report - 256-5-6, Cheyenne, WY.

Erickson, J. 1966. Summarization of life history and management studies on the Rocky Mountain whitefish in the Snake River Drainage, 1952-1964. Wyoming Game and Fish Department Administrative Report 0166-23-5501, Cheyenne, WY.

Fleming, F.A. 1939. The growth and food habits of small brook trout in natural rearing ponds of the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Garafolo, T.R. 1964. Studies on the ecology of the brook trout in the Rocky Mountain Region Part IV: A study of the population dynamics and trophic ecology of the brook trout in two subalpine lakes in southeastern Wyoming. Cooperative Research Project 2 U. WY and WY Game and Fish Commission, Cheyenne WY.

Garafolo, T. 1964. A study of the population dynamics and trophic ecology of brook trout in two subalpine lakes, in southeastern Wyoming Part VI. Wyoming Game and Fish Department Administrative Report - Cooperative Research, Cheyenne, WY.

Garofalo, T.R. 1964. A study of the population dynamics and trophic ecology of the brook trout in two subalpine lakes in southeastern Wyoming. Wyoming Game and Fish Department Unpublished Report Project F-23-R-4, Cheyenne, WY.

Gowan, C.; Young, M.K.; Fausch, K.D; Riley, S.C. 1994. The restricted movement of stream-resident salmonids: a paradigm lost? Canadian Journal of Fisheries and Aquatic Sciences 51: 2626-2637.

Grost, R.T. 1989. A description of brown trout redds in Douglas Creek, Wyoming. Master's Thesis. University of Wyoming.

Guenther, P.M. 1989. Minimum pool requirements for the enhancement and maintenance of salmonid fisheries in small Wyoming impoundments. Master's Thesis. University of Wyoming.

Harris, D.D. 1991. Brown trout populations in Douglas Creek, Medicine Bow National Forest: Population and habitat responses to enhanced minimum flow. Master's Thesis. University of Wyoming.

Harris, D.D.; Hubert, W.A.; Wesche, T.A. 1991. Brown trout population and habitat response to enhanced flow in Douglas Creek, Wyoming. Rivers 2: 285-294.

Holland, E. 1927. Preliminary study of the food of trout of the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Johnson, S.L. 1989. Factors influencing the size structure of brook trout populations in beaver ponds in southeastern Wyoming: management applications. Master's Thesis. University of Wyoming.

Johnson, K.; Oberholtzer, M. 1987. Investigation into possible occurrence of Colorado squawfish (*Ptocheilus lucius*) and other federally threatened or endangered fish species. Wyoming Game and Fish Department Administrative Report - 5086-13-8601, Cheyenne, WY.

Johnson, S. J.; Rahel, F.J.; Hubert, W.A. 1992. Factors influencing the size structure of brook trout populations in beaver ponds in Wyoming. North American Journal of Fish Management 12(1): 118-124.

Kanaly, J. 1963. 1963 Laramie River Study. Wyoming Game and Fish Administrative Report - 763-5-1, Cheyenne, WY.

---. 1962. An evaluation of the Pole Mountain Fisheries. Wyoming Game and Fish Department Administrative Report - 256-5-6, Cheyenne, WY.

---. 1969. An evaluation of trout stocking and harvest in the Upper North Platte River. Wyoming Game and Fish Department Administrative Report 05-000-010, Cheyenne, WY.

---. 1977. A fisheries survey of the Encampment River drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Administrative Report - 5074-01-7201, Cheyenne, WY.

Kanaly, J.; Oberholtzer, M.; Pedlar, D. 1971. A fisheries survey of streams, lakes and reservoirs in the Laramie River drainage 1964-1971. Wyoming Game and Fish Department Administrative Report - 0570-01-6401, Cheyenne, WY.

Kanaly, J.; Pedler, D. 1967. A fisheries survey of the streams and reservoirs of the South Platte River Drainage. Wyoming Game and Fish Department Administrative Report - Number 16, Cheyenne, WY.

Kanaly, J.; Williams, F; Mill, R. 1958. A fisheries survey of the Little Snake River Drainage 1954-1955. Wyoming Game and Fish Department Adminstrative Report - Number 6, Cheyenne, WY.

Kozel, S.J. 1987. Trends in habitat features and trout abundance among altered stream reaches on the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Kozel, S.; Hubert, W. 1989. Factors influencing the abundance of brook trout *Salvelinus fontanalis* in forested mountain streams. Journal of Freshwater Ecology 5 (1): 113-122.

Kozel, S.J.; Hubert, W.A.; Parsons, M.G. 1989. Habitat features and trout abundance relative to gradient in some Wyoming streams. Northwest Science 6(4): 175-182.

Kozel, S J.; Hubert, W.A. 1989. Testing of habitat assessment models for small trout streams in the Medicine Bow National Forest, Wyoming. North American Journal of Fisheries Management 9: 458-464.

Lanning, D.R. 1992. Evaluation of trout habitat restoration, Battle Creek, WY. Master's Thesis. University of Wyoming.

Larscheid, J.G.; Hubert, W.A. 1992. Factors influencing the size structure of brook trout and brown trout in southeastern Wyoming mountain streams. North American Journal of Fisheries Management 12: 109-117.

McDowell, R. 1975. A study of the Pole Mountain Fishery: beaver pond, artificial impoundment and stream investigations. Wyoming Game and Fish Department Admininstrative Report - F-44-R-01, Cheyenne, WY.

McMillan, J. 1989. A fishery and habitat survey of the Deer Creek drainage, Converse and Natrona County, Wyoming. Wyoming Game and Fish Department Administrative Report -, Cheyenne, WY.

---. 1990. A fishery and habitat survey of the La Prele Creek drainage, Converse County, WY. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.

Meyer, C. 1994. A fisheries inventory of the Chugwater Creek drainage, Platte, laramie and Albany Counties, Wyoming. Wyoming Game and Fish Department Administrative Report - 5094-01-9301, Cheyenne, WY.

Miller, A. 1989. Fishermen use survey of the lakes in the Snowy Range roadless area, 1988. Wyoming Game and Fish Department Adinistrative Report, Cheyenne, WY.

Miller, D. 1980. Quantification of trout habitat that could be impacted by Stage II of the proposed Cheyenne Water Development Project. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.

Oberholtzer, M. 1980. A comprehensive survey of the French Creek drainage, tributary to the Nroth Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5080-01- 7201, Cheyenne, WY.

---. 1981. A comprehensive survey of the Brush Creek drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5081-01-7201, Cheyenne, WY.

---. 1982. A comprehensive survey of the Jack Creek drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5081-01-7201, Cheyenne, WY.

---. 1983. A comprehensive survey of the Big Creek drainage, tributary to the North Platte River, Carbon County, Wyoming. Wyoming Game and Fish Department Administrative Report - 5082-01- 7201, Cheyenne, WY.

---. 1985. A comprehensive survey of the Medicine Bow River drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5084-01- 7201, Cheyenne, WY.

---. 1969. Evaluation of the effects of a two-year closure on the brook trout population of Little Brooklyn Lake. Wyoming Game and Fish Department Administrative Report - 0569-19-6602, Cheyenne, WY.

---. 1969. Evaluation of restrictive fishing on the Little Laramie River. Wyoming Game and Fish Department Administrative Report -0568-19-6701, Cheyenne, WY.

---. 1971. Evaluation of catchable rainbow planted in Battle Creek, Carbon County. Wyoming Game and Fish Department Administrative Report - 0570-14-7002, Cheyenne, WY.

---. 1986. A fisheries survey of the Spring Creek drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5085-01-7201, Cheyenne, WY.

---. 1986. A fisheries survey of the Pass Creek drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5085-01-7201, Cheyenne, WY.

---. 1987. A fisheries survey of the Little Snake River drainage, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5086-01-8501, Cheyenne, WY.

---. 1989. Fisheries management plan for Douglas Creek, a Class II stream in Albany County and Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5088-28-8401, Cheyenne, WY.

---. 1989. A fisheries survey of the Big Sage Creek drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5088-01-7201, Cheyenne, WY.

---. 1989. A fisheries survey of the Cow Creek drainage, tributary to the North Platte River, Carbon County, Wyoming. Wyoming Game and Fish Department Administrative Report - 5088-01- 7201, Cheyenne, WY.

---. 1990. A fisheries survey of the Beaver Creek drainage, tributary to the North Platte River, Carbon County, WY. Wyoming Game and Fish Department Administrative Report - 5089-01-7201, Cheyenne, Wy.

---. 1992. A fisheries inventory of the Little Laramie River drainage, Albany County, Wyoming. Wyoming Game and Fish Department Administrative Report 5091-01-9101, Cheyenne, WY.

---. 1980. Post-logging evaluation of Damfino Creek, Carbon County, 1977-1978. Wyoming Game and Fish Department Administrative Report - 5079-07-6901, Cheyenne, WY.

---. 1972. Return of catchable size trout, planted in the North Laramie River, Platte, County, WY. Wyoming Game and Fish Department Adminstrative Report - 0572-14-7001, Cheyenne, WY.

Oberholtzer, M.; Miller, D; Myer, C. 1993. A fisheries inventory of the Upper Laramie River drainage, Albany county, WY. Wyoming Game and Fish Department Administrative Report - 5092-01- 9101, Cheyenne, WY.

Oster, J. 1990. Rob Roy Reservor, Lake Owen and Douglas Creek fisherman use and harvest. Wyoming Game and Fish Department Administrative Report - 5089-02-8901, Cheyenne, WY.

Royer, L.M. 1960. A study of the ecology of the brook trout in Little Brooklyn Lake and Towner Lake,Medicine Bow Forest, Wyoming. Master's Thesis. University of Wyoming.

---. 1960. A study of the ecology of the brook trout in Little Brooklyn Lake and Towner Lake, Medicine Bow National Forest, Wyoming. Wyoming Game and Fish Commission, Cheyenne, WY Cooperative Research Project No. 2,

Sinn, J. 1961. A study of the brook trout in Libby Lake, Medicine Bow National Forest, in southeastern Wyoming Part V D.J. Project F-23-R-4. Wyoming Game and Filsh Department Administrative Report - Cooperative Research, Cheyenne, WY.

Sinn, J.A. 1962. A study of the brook trout in Libby Lake, Medicine Bow National Forest in southeastern Wyoming. Master's Thesis. University of Wyoming.

Stewart, R.K. 1959. A study of the scale markings and the age determination of certain brook trout populations in the Rocky Mountain Region of southeastern Wyoming. Wyoming Game and Fish Department Administrative Report - Cooperative Research, Cheyenne, WY.

Wesche, T. et al. 1987. Modified habitat suitablity index model for brown trout in Southeastern WY. North American Journal of Fish Management 7: 232-237.

Western Water Consultants. I. 1989. Project completion report: Green Timber Creek fish habitat restoration project, Hayden District, Medicine Bow National Forest. Western Water Consultants, Laramie, Wyoming.

White, J. R. 1965. A study of brook trout population ecology with emphasis on egg and fry mortality Part VIII. Wyoming Game and Fish Department Administrative Report - Cooperative Research, Cheyenne, WY.

Winkle, P.L.; Hubert, W.A.; Rahel, F.J. 1990. Relations between brook trout standing stocks and habitat features in beaver ponds in southeast Wyoming. North American Journal of Fisheries Management 10: 72-79.

Wolff, S.W. 1987. Evaluation of trout habitat formation due to flow enhancement in a previously ephemeral stream. Master's Thesis. University of Wyoming.

Yekel, S.D. 1978. Food and feeding habits of rainbow and brown trout in the Upper North Platte River, Carbon County, WY. Master's Thesis. University of Wyoming.

Yekel, S. 1978. Food and feeding habits of rainbow and brown trout populations in beaver ponds in southeastern Wyoming. Wyoming Game and Fish Administrative Report, Cheyenne, WY.

Young, M.K. 1994. Brown trout mobility in south-central Wyoming streams. Canadian Journal of Zoology 72: 2078-2083.

Young, M.K. 1995. Telemetry-determined diurnal positions of brown trout (*Salmo trutta*) in two south-central Wyoming streams. American Midland Naturalist 133: 264-273.

Young, M.K.; Haire, D.; Bozek, M.A. 1994. The impact and extent of railroad tie drives in streams of southeastern Wyoming. Western Journal of Applied Forestry 9: 125-130.

Young, M.K.; Hubert, W.A.; Wesche, T.A. 1989. Substrate modification by spawning brook trout in a southeastern Wyoming stream. Transactions of the American Fisheries Society 118:379-385.

Young, M.K.; Schmal, R.N. 1995. Mobile trout: consequences of a new paradigm. Pages 185-188 *in* R. Barnhart, B. Shake, and R.H. Hamre, technical editors. Proceedings of Wild Trout V: wild trout in the 21st century. Yellowstone National Park, 26-27 September 1994.

STREAMS - STRUCTURE, FUNCTION, CONDITION

Grost, R.T.; Hubert, W.A. 1991. Field comparison of three devices used to sample substrate in small streams. North American Journal of Fisheries Management 11: 347-351.

Hipple, B. 1986. Summary of washout at Deadman Creek, First Creek, Second Creek and Rose Creek on Stage II Little Snake River Diversion pipeline. Medicine Bow National Forest Specialist Report, Laramie, WY.

Jespersen, D.M. 1983. Effects of sediment on Hog Park Creek, Medicine Bow National Forest. Medicine Bow National Forest Specialist Report, Laramie, WY.

---. 1980. Instream flow determinations for streams effected by Stage I and Stage II of the City of Cheyenne water development project in the Douglas Creek drainage and supplemental flow recommendations in the North Fork of the Little Snake River Drainage. Medicine Bow National Forest Specialist Report, Laramie, WY.

Jones, D.W. 1950. A study of the seasonal changes in the animal population of a temporary pond in the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Kimble, L.A.; Wesche, T.A. 1975. Relationships between selected parameters and benthic community structure in a small stream. Water Resources Research Institute, University of Wyoming, Laramie, Wyoming.

Lowry, S. 1988. An economic evaluation of using instream structures for restoring degraded riparian zones in Wyomng. Master's Thesis. University of Wyoming.

Marston, R. A.; Wick, D.A. 1994. Natural variability and forestry impacts in mountain streams of southeastern Wyoming. Proceedings of the American Water Resources Association Symposium - Effects of Human-Induced Changes on Hydraulic Systems, Jackson Hole, WY, 26 June 1994.

Pogge, A.F. 1962. A study of hydrarch succession in the subalpine zone of the Snowy Range west of Laramie. Master's Thesis. University of Wyoming.

Schmal, R.N. 1987. Deadman Creek diversion failure: assessment of changes in physical stream habitat and aquatic macroinvertebrates with recommendation for mitigation. Medicine Bow National Forest Specialist Report, Laramie, WY.

Schmal, R.; Wesche, T. 1989. Historical implications of the railroad crosstie industry on current riparian and stream habitat management in the Central Rocky Mountains. Practical Approaches to Riparian Resource Management, (Gresswell et. al. (eds), Billings, MT, 8 May 1989.

USDA Forest Service - Medicine Bow National Forest. 1980. Final Environmental Impact Statement 02-06-80-02 Cheyenne Stage II Water Diversion. Medicine Bow National Forest, Laramie, WY.

Vogt, G.F., Jr.; Annear, T.C. 1989. Encampment River Instream Flow Report. Wyoming Game and Fish Department Administrative Report - IF-5088-07-9901, Cheyenne, WY.

Vogt, G.F. Jr.; Wesche, T. 1991. Instream flow report for streams affected by the City of Cheyenne's Stage II Water Development Project. Wyoming Game and Fish Department Administrative Report - IF-5090-07-9001, Cheyenne, WY.

Water Resources Research Institute. 1976. Determining instream flows for management of aquatic and riparian Ecosystems Volume II Review of literature. University of Wyoming Water Resources Research Institute, Laramie, WY.

---. 1978. Determining instream flows for management of aquatic and riparian ecosystems Volume III Research Needs. University of Wyoming water Resources Research Institute Cooperative Agreement 16-556-CA, Laramie, WY.

Wesche, T.A. 1987. Determination of a mitigative flushing flow regime for Deadman Creek, Medicine Bow National Forest Final Report. Habitech, Laramie, WY.

---. 1973. Parametric determination of a minimum streamflow for trout. Master's Thesis. University of Wyoming.

Wesche, T.A.; Hasfurther, V.R.; Q.D. Skinner. 1987. Recommendation and evaluation on a mitigative flushing flow regime below a high mountain diversion. Proceedings, Symposium on Water Resources related to Mining and Energy - Perparing for the Future, 1987. Bethesda, MD: American Water Resources Association.

Wesche, T.A.; Reiser, D.W.; Wichers, W.F.; Wichers, D.L. 1977. Fishery resources and instream flow recomendations for streams to be impacted by Cheyenne's proposed Phase II Development. Report for Wyoming Game and Fish Department, Cheyenne, WY.

Wick, D.A. 1993. Separation of clearcutting impacts from natural channel variability in mountain streams of the Medicine Bow National Forest, Wyoming. Master's Thesis. University of Wyoming.

Wilcox, M. 1984. Water flows required for "favorable conditions of water flows" on the proposed Little Snake River project, Medicine Bow National Forest. Medicine Bow National Forest Specialist Report, Laramie, Wyoming.

HIGH ELEVATION LAKES

Baquerizo, E.A. 1986. Alkalinity and pH of high mountain lakes, ponds and streams in the Snowy Range, Southeast Wyoming. Plan B Paper Master's Thesis. Agricultural Engineering and Wyoming Water Resources Center, University of Wyoming.

Baxter, G.T. 1959. Experimental fertilization of an alpine lake in Wyoming. Cooperative Research project 3 U. WY and WY Game and Fish Commission. University of Wyoming.

Baxter, G. 1975. Lake Fisheries. IN: The Medicine Bow ecology project. D.H. Knight (ed.) Laramie, WY. University of Wyoming.

Baxter, G.T. 1957. A study of the effect of fertilization on trout growth in an alpine lake in Wyoming. Wyoming Game and Fish Department Unpublished report Project F-7-R-3, Cheyenne, WY.

Bennett, J.R. 1981. Some effects of manipulating a natural brook trout population in a subalpine lake. PhD Dissertation. University of Wyoming.

Condit, S.H. 1974. A simulation model investigation of the effects of spring runoff on a subalpine lake phytoplankton population. Master's Thesis. University of Wyoming.

Glass, J.T. 1934. A study of Lakes Irene and Swastika as short season rearing ponds for brook trout (*Salvelinus fontalis*). Master's Thesis. University of Wyoming.

Hepworth, W.G. 1959. A study of the population dynamics of brook trout in the two subalpine lakes in southeastern Wyoming. Master's Thesis. University of Wyoming.

---. 1959. A study of the population dynamics of brook trout in two subalpine lakes in southeastern Wyoming. Wyoming Game and Fish Department D.J. Project F-23-R-2 part 2, Cheyenne, WY.

Kanaly, J. 1966. Chemical treatment of Bear Lake, Albany County, WY. Wyoming Game and Fish Department Administrative Report - 364- 5-1, Cheyenne, WY.

---. 1969. Lake Owen management specifically relating to trout stocking. Wyoming Game and Fish Department Administrative Report - 0569-14-6501, Cheyenne, WY.

Miller, D. 1985. A comprehensive Survey of the Medicine Bow drainage, Carbon County, Wyoming. WY Game and Fish. Cheyenne, Wyoming.

Miller, A.L. 1989. Geomorphic controls on winterkill conditions in alpine lakes of the Snowy Range, Wyoming. Master's Thesis. University of Wyoming.

Parker, M.; Payne, F. 1980. Effects of nutrient enrichment in a subalpine oligotrophic lake in southeastern Wyoming. Eisenhower Consortium Contract No 16-898-GR for USDA Forest Service, Laramie, WY.

Payne, F.E. 1983. Response of phytoplankton and zooplankton to nutrient enrichment in Big Brooklyn Lake, Wyoming. PhD Dissertation. University of Wyoming.

Simon, F. 1938. A survey of lakes and streams in the Medicine Bow National Forest, Wyoming. Master's Thesis. University of Wyoming.

Snigg, M.A. 1989. Snowy Range Lakes Survey. Wyoming Game and Fish Department Administrative Report - 5089-01-8701, Cheyenne, WY.

Wagner, J.F. 1971. The primary productivity of limiting nutrients of Little Brooklyn Lake. Master's Thesis. University of Wyoming.

Wesche, T.A. 1991. Flushing flow requirements of mountain stream channels. Wyoming Water Research Center and Department of Range Management, University of Wyoming, Laramie, Wyoming, Laramie, Wyoming.

Wyoming Game and Fish Department FM-50. 1964. A survey of the Snowy Range Lakes, Medicine Bow National Forest, Wyoming 1956- 1962. Wyoming Game and Fish Department Adminstrative Report - 0573-01-5504, Cheyenne, WY.

WATER QUALITY

Adams, J.C. 1989. Bacteriological aspects of a mountain watershed. Toxicity Assessment: An International Journal 4: 309-315.

Adams, J.C.; Skinner, Q.D. 1984. Water quality near ski areas, Medicine Bow National Forest. Final Report Eisenhower Consortium Wy Project 16-516-CA University of Wyoming Water Research Institute, Laramie, WY.

Gary, H.L.; Adams, J.C. 1985. Indicator bacteria in water and stream sediments near the Snowy Range on southern Wyoming. Water, Air and Soil Pollution 25: 133-144.

Hussey, M.R. 1984. Change in bacterial populations in Wyoming mountain streams after ten years, and distribution of denitrifying and sulfate-reducing bacteria in riparian soils. Master's Thesis. University of Wyoming.

Parker, R.; Elder, G.; Payne, F.E. 1980. Predicting aspects of water quality from phosphorus mass budget models and algal bioassays. Eisenhower Consortium Contract No 16-586-GR EC#196 for USDA Forest Service, Laramie, WY.

Skinner, Q.D. 1974. Bacteriology and associated vegetation of a high mountain watershed. PhD Dissertation. University of Wyoming.

---. 1970. Water quality of a glaciated mountain lake as influenced by recreation users. Master's Thesis. University of Wyoming.

Skinner, Q.D.; Adams, J.C.; Beetle, A.A.; Roehrkasse, GP. 1984. Change in bacterial populations downstream in a Wyoming mountain drainage basin. Journal of Range Management 37(3): 269- 274.

Skinner, Q.D.; Adams, J.C.; Rechard, P.A.; Beetle, A.A. 1974. Effect of summer use of a mountain watershed on bacterial water quality. Journal of Environmental Quality 3 (4): 329-335.

---. 1974. Enumeration of selected bacterial populations in a high mountain watershed. Canadian Journal of Microbiology 20(1): 1487-1492.

Speck, J.E. 1981. A comparative study of the effects of continuous season-long and deferred rotation grazing on mountain riparian vegetation and water quality. Master's Thesis. University of Wyoming.

WATER CHEMISTRY, ATMOSPHERIC POLLUTION AND CLIMATE CHANGE

Couch, C.G. 1941. Hydrogen ion concentrations and diatoms in certain lakes of the Medicine Bow Mountains of Wyomng. University of Wyoming Publications 8(5):69-83

Fox, D.G.; Schoettle, A.W.; Vertucci, F.A. 1987. Glacier Lakes Ecosystem Experiments Site: An "experimental" wilderness. IN: Management of subalpine forests: building on 50 years of research - Proceedings of a Technical Conference, 161-166. Silver Creek, Colorado, 6 July 1987. USDA Forest Service General Technical Report RM-149.

McKenna, M.A. 1992. Atmospheric effects on plant reproduction. Unpublished Report RMFRES Library, Fort Collins, CO, Final Report Cooperative Agreement No 28-CO-527 Howard University and USFS.

---. 1990. Effects of atmospheric processes on natural ecosystems Final Report USFS Cooperative Agreement No 28-C8-490 GLEES. Howard University, Washington, D.C.

---. 1994. Genotypic and phenotypic components of alpine plant response to acid rain. Howard University Final Report GLEES Cooperative agreement 28-C2-595 (FRS #6-34531), Washington, D.C.

Mosier, A.R.; Klemmedtson, L.K; Sommerfeld, R.A. Musselman, R.C. 1993. Methane and nitrous oxide flux in a Wyoming subalpine meadow. Global Biogeochemical Cycles 7 (4): 771-784.

Rechard, P.A.; Smith, V.E. 1972. Physical and hydrometerological characteristics of the Snowy Range Observatory. Water Resources Series 30 University of WY, Laramie, WY.

Reuss, J.O.; Vertucci, F.A.; Musselman, R.C.; Sommerfeld, R.A. 1993. Biogeochemical fluxes in the Glacier Lakes catchments. USDA Forest Service Research Paper RM-314, Fort Collins, CO.

Reuss, J.O. 1994. Application of the MAGIC model to the Glacier Lakes catchments. USDA Forest Service Research Paper RM-315. Fort Collins, CO.

Sommerfeld, R.A.; Mosier, A.R.; Musselman, R.C. 1993. CO_2, CH_4, and $N0_2$ flux through a Wyoming snowpack and implications for global budgets. Nature 361: 140-142.

Wooldridge, G.; Musselman, R.; Connell, B.; Fox, D. 1992. Airflow patterns over a small subalpine basin. Theoretical and Applied Climatology 45: 37-41.

Zeller, K.; Hehn, T. 1994. Wintertime anomalies in ozone deposition above a subalpine fire forest. IN: Research and Applications in Chemical Sciences in Forestry, 131-138. Starkville, Mississippi, 31 January 1902. USDA Forest Service General Technical Report SO-104.

RECENT MBNF SPECIALIST REPORTS CONCERNING BIOLOGICAL DIVERSITY

Erhard, D. 1989. Douglas District riparian project FY89. Specialist Report- Douglas Ranger District, Medicine Bow National Forest, Douglas, WY

Harper, J. 1994. White Swan/Holmes timber sale biodiversity report. USDA Forest Service Specialist report- Laramie Ranger District, Laramie, WY.

Jones, G.P. 1989. Report on the Ashenfelder Basin Special Interest Area. USDA Forest Service Medicine Bow National Forest, Laramie, WY.

Mastel, J. 1994. Cedar Timber sale Specialist Report for ecology, wildlife and range. USDA Forest Service Brush Creek District Medicine Bow National Forest, Laramie, WY

US Forest Service/Hayden Ranger District/Medicine Bow National Forest. 1993. Deep Creek timber sale biodiversity report IN: Deep Creek Environmental Assessment. USDA Forest Service Medicine Bow National Forest,

von Ahlefeldt, J. 1995. Composition and structure of vascular plant communities, and mycorrhizal infection of conifer and *Vaccinium* in clearcuts, 1950-1992, compared to uncut lodgepole pine and spruce-fir forest. Ecologist Specialist Report (In Preparation) Medicine Bow National Forest, Laramie, WY.

---. 1993. Medicine Bow National Forest sensitive plant species (R-2 List) and Species of Special Concern (Nature Conservancy). Unpublished Specialist Report, Medicine Bow National Forest, Laramie, WY.

---. 1995. Riparian community types of the Northern Laramie Range. Specialist Report (In preparation) Medicine Bow National Forest, Laramie, WY.

Wilcox, M. 1989. Green Timber Creek timber sale Specialist report. Medicine Bow National Forest Specialist Report, Laramie, WY.

PLANNING AND MONITORING (1985-1994)

Bruscino, M.; Miller, D.D. 1985. Stage II Environmental survellience. Wyoming Game and Fish Department Administrative Report - 5085-07-8301 and 50, Cheyenne, WY.

---. 1987. Stage II and III Environmental survelliance and inventory. Wyoming Game and Fish Adminstrative Report - 5086-07- 8301 and 50, Cheyenne, WY.

Donovan, K.E. 1992. The public's role in Forest service Planning: Citizen Involvement in the Proposed Threemile timber sale. Master's Thesis. University of Wyoming.

Gleisner, J.L. 1985. Road obliteration on the Medicine Bow National Forest: An analysis of site parameters and ther effect on revegetation. Master's Thesis. University of Wyoming.

Koehler, B.N. 1973. An evaluation of wilderness potential of sixteen areas in the Medicine Bow National Forest. Master's Thesis. University of Wyoming.

Miller, P. 1988. Critical aspects of citizen participation in Forest Service Planning. Master's Thesis. University of Wyoming.

Ryan, M.G.; Joyce, L.A.; Andrews, T.; Jones, K. 1994. Research Natural Areas in Colorado, Nebraska, North Dakota, South Dakota and part of Wyoming. U.S. Forest Service General Technical Report RM-251, Forest Collins, CO.

USDA Forest Service Medicine Bow National Forest. 1985A. Final Environmental Impact Statement Medicine Bow NAtional Forest and Thunder Basin National Grassland Volume 1 Chapter 1-5, 7-9 and Appendices. Medicine Bow National Forest, Laramie, WY.

---. 1985B. Land and Resource Management Plan Medicine Bow National Forest and Thunder Basin National Grassland. Medicine Bow National Forest, Laramie, WY.

USDA Forest Service - Medicine Bow National Forest. 1994A. Watershed and Stream Rehabilitation Plan for Upper Douglas Creek. Plateau Environmental Services, Inc., Durango, Colorado.

USDA Forest Service- Medicine Bow National Forest. 1994B. Watershed and Stream rehabilitation plan for Upper Douglas Creek. Plateau Environmental Services, Inc., Durango, Colorado.

Williams, S.E.; Marvel, C.C. 1990. The Snowy Range Road: A high altitude, High Visability reconstruction project. IN: W.R. Keammmerer and J.Todd (eds.) Proceedings of the 9th High Altitude Revegetation Conference. Information Series #63, Water Research Insititute, Colorado State University, Fort Collins, CO

HISTORICAL DESCRIPTIONS

Armstrong, P.L. 1935. History of the Medicine Bow National Forest Service. Unpublished manuscript, Wyoming State Archives and Historical Department, Cheyenne, WY.

Author unknown. 1905. Report on the Medicine Bow Forest Reserve. Unpublished Administrative Report On File - Medicine Bow Collection American Heritage Center University of Wyoming Box 8.

Bates, C.G. 1926. Natural Areas and Regions - 10. National Forests of the Rocky Mountain District. IN: Naturalists Guide to the Americas. V.E. Shelford, 237-249. Baltimore, MD: The Williams and Wilkins Company.

Blackhall, J. 1915. Information on Hayden National Forest. Unpublished Administrative Report On File in Medicine Bow Collection American Heritage Center University of Wyoming,

Bruce, R.K. 1959. History of the Medicine Bow National Forest, 1902-1910. Master's Thesis, History. University of Wyoming.

Collins, J.S. 1904. The hunter's paradise. Across the plains in '64. Omaha, NE: Private Printing.
Duncan, M. 1990. The Medicine Bow mining camps. Laramie, Wyoming: Jelm Mountain Publications.

---. 1992. Place names of the Medicine Bow National Forest. Jelm, WY: Jelm Publications.

Dunlap, F. 1906. Report on dead and mature timber in the Cheyenne Forest Reserve, Colorado and Wyoming. USDA Forest Service Unpublished report.

Duthie, G.A. 1916. The Medicine Bow National Forest, 1913-1916. Unpublished Administrative Report On file Box 4 - Medicine Bow Collection American Heritage Center University of Wyoming,

Ensign, E.T. 1888. Report on the forest conditions of the Rocky Mountains - especially in the State of Colorado, the Territories of Idaho, Montana, Wyoming and New Mexico pages 111-112 (Albany and Carbon Counties, WY). USDA Forestry Division, Bulletin No. 2, Washington, D.C.

Fernow, B.E. 1888. Annual report of the Division of Forestry Wyoming pages 137-138. U.S.Government Printing Office, Washington, D.C.

Fremont, J.C. 1845a. Report on the exploring expeditions of the Rocky Mountains pages 120-127. Blair and Rives, Printed by Order of the House of Representatives Washington, D.C.

Fremont, J.C. 1845b. Map portfolio of the expeditions of John Charles Fremont. University of Chicago Press, Urbana, Ill.

Governor of Wyoming. 1891. Report of the Governor of Wyoming to the Secretary of the Interior IN: The Executive Documents of the House of Representatives. U.S. Government Printing Office, Washington, D.C.

Grasso, D.N. 1982. A cultural resource overview of the Medicine Bow National Forest and Thunder Basin National Grassland. Report Prepared for the Medicine Bow National Forest, Laramie, WY.

Hayden, F.V. 1871. 4th Annual Report of the United States Geological Survey for Wyoming and portions of contiguous territories. U.S. Department of the Interior, United States Geological Survey pages 11-25; 76-81; 112-130, Washington, D.C.

Hermann, B. 1897. Forest Fires - Report of the Commissioner of General Land Office pages 80-86 IN: Annual Reports of the Department of the Interior. U.S. Government Printing Office, Washington, D.C.

Hess, F.L. 1926. Platinum near Centennial, WY. U.S. Geological Survey Bulletin No 780-C,

Houghton, M.D. 1904. Views of Southern Wyoming - Copper Belt Edition. Grand Encampment, WY: Herald Publishing CO.

Hollenback, F.R. 1960. The Laramie Plains Line. Denver, CO: Sage Books.

Homsher, L.M. 1949. The history of Albany County, Wyoming to 1880. Master's Thesis. University of Wyoming.

Lovejoy, P.S. 1909. Report for Forest Atlas. Administrative Report on File in Medicine Bow Collection, American Heritage Center, University of Wyoming Laramie, WY,

Martin, W.A. 1951. Light in darkness: A tale of the early LaBonte. Casper, WY: Mountain States Lithography.

Messerschmidt, D.A. 1972. The Grand Encampment. Encampment, Wyoming: The Grand Encampment Museum.

Mullison, J.H. 1909. Report for the Forest Atlas. Administrative Report on File in the Medicine Bow Collection, American Heritage Center University of Wyoming, Laramie, WY.

Mullison, J.H.; Lovejoy, P.S. 1909. History of the Cheyenne National Forest. Unpublished Administrative Report on file-Medicine Bow Collection American Heritage Center University of Wyoming, Laramie, WY.

Neal, C.R. 1986. In pursuit of Parkman. Journal of the West October: 49-61.

Parkman, F. 1950. Chapters 13, 17, 18, 19. IN: The Oregon Trail.New York: Mentor Books.

Pinchot, G. 1899. Forest fires IN: Department Reports; Report of THE FORESTER for 1899, Report of the Secretary of Agriculture page 98. USDA, Washington, D.C.

Report of Commissioner of General Land Office. 1901. Creation of the Crow Creek Forest Reserve, Wyoming pp. 452-455 and Expansion of the Forest Fire Law pages 153-154 IN: Annual Reports of the Department of the Interior 57th Congress House of Representatives Document No. 5. U.S. Government Printing Office, Washington, D.C.

Rose, J.A. 1987. A cultural resource evaluation of the Knight Science Camp (48AB138). Report prepared for the State Office of Historical Preservation, Cheyenne WY by the Medicine Bow National Forest, Laramie, WY.

Rosenberg, R.G. 1984. Handhewn Ties in the Medicine Bows. Annals of Wyoming 56 (1): 39-55.
Rydberg, P.A. 1913. Phytogeographical Notes on the Rocky Mountain Region I. Torrey Botanical Club 40: 677-686.

Surveyor-General of the Wyoming Territory. 1874. Report of the surveyor General of Wyoming Territory pages 255-259 IN: Report of the Secretary of the Interior to the two Houses of Congress Volume 1. Government Printing Office, Washington, D.C.

Territory of Wyoming. 1890. Report of the Territory of Wyoming to the Secretary of the Interior page CXXII IN: The Executive Documents of the House of Representatives. U.S. Government Printing Office, Washington, D.C.

Thybony, S.; Rosenberg, R.G.; Rosenberg, E.M. 1985. The Medicine Bows- Wyoming's Mountain Country. Caldwell, Idaho: The Caxton Press.

Torrey, J. 1845. Catalogue of Plants collected by Lieut. Fremont in his Expedition to the Rocky Mountains. Smithsonian Institution Press, Washington, D.C.

USDA Forest Service Medicine Bow National Forest. 1994. The Medicine Bow National Forest Collection. Account Number 3654 35 boxes of Forest Service Records on file at the American Heritage Center University of Wyoming.

van Zandt, F.K. 1966. Boundaries of the United States and the Several States Wyoming pages 233-234. U.S. Government Printing Office, Washington, D.C.

Veeder, J.S.; Ericson, E.R.; Lerchen, R.A.; Beals, W.F.; Mahan, S.A.; Riggs, R.R.; Coughlin, L.E. February 1932. The Medicine Bow National Forest. The Bulltein - Rocky Mountain Region Vol 19 No. 2, Denver, CO.

Wade, M. 1943. The journals of Francis Parkman. pages 452-471. London: Eyre and Spottiswoode.

Wiley, R.W. 1993. Wyoming Fish Management, 1869-1993. Wyoming Game and Fish Department Administrative Report, Cheyenne, WY.

Wood, D.R. 1988. Medicine Bow tie hack resources: Material culture and social structure. Master's Thesis. University of Wyoming.

___. 1990. Cultural Resource Inventory for Snowy Range Capital Improvement Project. On file. Medicine Bow National Forest. Laramie, WY.

___. 1991. Cultural Resources Inventory for Vedavoo Capital Improvement Project. On file. Medicine Bow National Forest. Laramie, WY.

Wood, D. 1994. Conservation and fire detection on the Medicine Bow National Forest. Unpublished Report by Deana Wood, Archeologist, Medicine Bow National Forest, Laramie, WY.

---. 1994. Tie Hacking on the Medicine Bow National Forest. Draft Report by Deena Wood, Archaeologist Medicine Bow National Forest, Laramie, WY.

---. 1994. Cultural Resources Inventory for the Morgan/Albany Land Exchange. On file. Medicine Bow National Forest. Laramie, WY.

___. 1995. Cultural Resources Inventory for the White Swan-Holmes Timber Sale. On file. Medicine Bow National Forest. Laramie, WY.

Young, M.K.; Haire, D.; Bozek, M.A. 1994. The effect and extent of railroad tie drives in streams of southeastern Wyoming. Western Journal of Applied Forestry 9 (4): 125-130.

Young, M. K.; Schmal, R.N.; Sobczak, C.M. 1989. Railroad tie drives and stream channel complexity: past impacts, current status and future prospects. SAF National Conference Wildlife and Fish Session, Spokane, WA, 24 September 1989.

APPENDIX 2

WATERSHEDS, BIODIVERSITY AREAS AND UNITS

5th AND 6th LEVEL WATERSHEDS
MEDICINE BOW NATIONAL FOREST

National direction for Forest Planning and Management is to use a Watershed-Based Ecosystem Management Approach.

This appendix shows the organization of the Medicine Bow National Forest Landscape by watershed-based Biological Diversity Areas (BDA's or groups of BDU watersheds) and Biological Diversity Units (BDUs - 5th, 6th or 7th level watersheds). BDUs may be individual 5th, 6th or 7th level watersheds, or groups of small watersheds of 6th ot 7th level. There are 16 BDAs and 96 BDUs.

General locations of BDAs and BDUs within each mountain range are in Figures AP2a-d. A summary of organization of BDA's and BDU's is in Table AP2.1. The number of 5th and 6th level watersheds is in Table AP2.2. Acreages for BDUs are in Table AP2.3. Watershed names are in Table AP2.4. For more precise locations of watershed boundaries 1:100,000 watershed maps which have the 16-digit watershed code numbers, or 1:24,000 topographic maps should be used.

Watersheds are organized into Biological Diversity Analysis Areas, which are subdivisions of the mountain ranges on watershed divides. This organizational system is not part of the official National Ecological Hierarchy, but fits into draft Section and Subsection levels. Landtype Associations and Landtypes are still in the developmental stage at the National and Regional Level.

Fifth and sixth level USGS watersheds will be used in the Forest Plan Revision. Sixth level watersheds are the basic unit for Integrated Resource Inventories (IRI).

The official designations for USGS watersheds uses a sixteen digit number. Each pair of numbers is unique to a watershed level. The first pair indicates the first level, the second pair, the second level and so forth. In the table below the digit pairs for the 1st, 2nd and 3rd levels are shown as a group of six numbers. The 4th, 5th and 6th levels are shown as three separated sets of digits, the 7th and 8th level are reserved by four zeros (which are indicated by a dash [-] to save space. Example: USGS CODE 1405000306030000. In this example, 140500 indicates the 1st, 2nd and 3rd levels; 03 06 03 indicate the 4th, 5th and 6th levels

respectively; the four zeros which are reserved for the 7th and 8th levels may also be shown by dashes (-).

A simplfied numbering system for these watersheds (1-96) is used in this Biological Diversity Analysis.

Acreage figures attached to BDU's abd BDA's were generated from Geographic Information System measurements of the RIS database. The GIS figures differ somewhat from both RIS acreages and previously published figures in the 1985 Forest Plan. There are many reasons for these differences, some of which are inherent in the computer methodology used to measure areas of polygons and rounding of numbers. In some cases, the acreages for polygons recorded in the RIS databse do not match the GIS measurements. Forest-wide, the difference is about 2%. Differences between RIS and GIS acres may be more or less than that for discreet areas. All acreage measurements and their accompanying percentages presented in this report use GIS acres unless the data dictated using acreages from some other sources. For example, in the Fire Occurrence Appendix (#15), acreages for Class E and Class F fires were obtained from the Fire Records logs, not from GIS measurements from the RIS database.

Figures for National Forest Acreages may be Gross Acres (all acres within the Administrative Boundary) or Net ACres (only NFS-owned lands within the Administrative Boundary).

TABLE AP2.1 BIOLOGICAL DIVERSITY ANALYSIS AREAS

SIERRA MADRE MOUNTAINS

Sierra Madre Northwest BDA
BDU - 1,2,3,13,14,15,16

Sierra Madre Southwest BDA
BDU - 4-12

Sierra Madre Encampment River BDA
BDU - 17-22

Sierra Madre Southeast BDA
BDU 23-26

MEDICINE BOW MOUNTAINS

Snowy Range North - West BDA
BDU 27-39
Snowy Range North - East BDA
BDU - 60-67
Snowy Range North - East Central BDA
BDU - 56-59
Snowy Range South - Wilderness BDA
BDU - 40-42
Snowy Range South - Central BDA
BDU - 43-50
Snowy Range South - East BDA
BDU - 51-54

SHERMAN MOUNTAINS

BDU - 68-70

LARAMIE MOUNTAINS

Laramie Mountains North - Northwest BDA
BDU - 71-80
Laramie Mountains North - Northcentral BDA
BDU - 81-84
Laramie Mountains South - Southcentral BDA
BDU - 85-89
Laramie Mountains South - Southwestern BDA
BDU - 90-92
Laramie Mountains South - Southern BDA
BDU 93-96

TABLE AP2.2 WATERSHEDS AND MOUNTAIN RANGES

WATERSHED COUNT	5th Level	6th Level
Sierra Madre Mountains	10	45
Medicine Bow Mountains	16	67
Sherman Hills	6	13
Laramie Mountains	13	29
Total	45	154

TABLE AP2.3 Gross and net NFS acres in each Biodiversity Analysis Area (BDA) and total gross and net acres for each mountain range. Acreages are from GIS.

Mountain Range Biodiversity Analysis Area	Gross Ac	Net Ac
SIERRA MADRE MOUNTAINS	**362,303**	**336,124**
Sierra Madre Northwest BDA	106,673	102,756
Sierra Madre Southwest BDA	131,526	115,747
Sierra Madre Encampment River BDA	76,286	72,245
Sierra Madre Southeast BDA	47,817	45,376
MEDICINE BOW MOUNTAINS	**532,513**	**512,243**
Snowy Range North - West BDA	140,410	133,578
Snowy Range North - East BDA	100,832	97,948
Snowy Range North - East Central BDA	68,279	67,865
Snowy Range South - Wilderness BDA	57,696	57,573
Snowy Range South - Central BDA	95,530	92,521
SHERMAN MOUNTAINS	**55,791**	**55,408**
LARAMIE MOUNTIANS	**437,733**	**178,161**
Laramie Mts. N.- Northwest BDA	137,666	52,846
Laramie Mts. N.- Northcentral BDA	72,554	27,887
Laramie Mts. South - Southcentral BDA	97,745	48,647
Laramie Mts. South - Southwest BDA	65,061	35,961
Laramie Mts. - Southern BDA	64,708	12,820
TOTAL ACRES MEDICINE BOW NATIONAL FOREST	**1,388,431**	**1,081,936**

* Gross acreage is all land within the Medicine Bow National Forest Administrative Boundary. It includes state and private land as well as NFS land, GIS analyses for stand age, cover type, old growth scorecard, and riparian areas are done on Net NFS acres. Net NFS acres refer to land in Federal ownership.

TABLE AP2.3 Acreages for Biodiversity Areas and Biodiversity Units (Gross NFS acres - from GIS)

Category Information / Biodiversity Unit	acres	hectares
SIERRA MADRE MOUNTAINS		
1 Sierra Madre Northwest	106,673.54	43,170.19
2 Sierra Madre Southwest	131,526.41	53,228.01
3 Sierra Madre Encampment River	76,286.44	30,872.70
4 Sierra Madre Southeast	47,817.24	19,351.37
TOTAL FOR SIERRA MADRE MOUNTAINS	**362,303.63**	**146,622.27**
MEDICINE BOW MOUNTAINS		
5 Snowy Range North - West	140,410.77	56,823.46
13 Snowy Range North - East	100,831.80	40,806.07
14 Snowy Range North - East Central	68,279.86	27,632.48
16 Snowy Range South - East	69,764.63	28,233.36
17 Snowy Range South - Wilderness	57,696.12	23,349.30
18 Snowy Range South - Central	95,530.19	38,660.54
TOTAL FOR MEDICINE BOW MOUNTAINS	**532,513.37**	**215,505.21**
LARAMIE MOUNTAINS		
6 Laramie Mtns North - Northwest	137,666.11	55,712.71
7 Laramie Mtns North - North Central	72,554.37	29,362.35
8 Laramie Mtns South - South Central	97,744.61	39,556.70
9 Laramie Mtns South - Southwest	65,060.61	26,329.67
12 Laramie Mtns South - Southern	64,707.58	26,186.80
TOTAL FOR LARAMIE MOUNTAINS	**437,733.28**	**177,148.23**
SHERMAN MOUNTAINS		
15 **Sherman Mountains**	55,790.930	22,578.280
TOTAL FOR SHERMAN MOUNTAINS	**55,790.930**	**22,578.280**

Total Acres Medicine Bow National Forest **1,388,341.21**

Category Information Biodiversity Unit		acres	hectares
LARAMIE MOUNTAINS			
71	West Fork Deer Creek	5094.83	2061.85
72	Bates Creek.	2907.30	1176.57
73	Upper Deer Creek	34,920.81	14,132.26
74	Virden Creek	5838.13	2362.66
75	Box Elder Creek.	20,665.86	8363.36
76	East Box Elder Creek	15,020.25	6078.61
77	Standing Rock Creek.	6714.10	2717.16
78	Meadow Creek	20,811.50	8422.30
79	Little Medicine Bow River.	10,439.75	4224.91
80	Sheep Creek.	15,253.56	6173.03
81	Rocky Ford Creek	5842.48	2364.42
82	Latham Creek	6101.20	2469.12
83	West Fork LaBonte Creek.	9328.94	3775.37
84	LaBonte Creek.	51,281.75	20,753.44
85	Mill Creek	1782.60	721.41
86	Lower Horseshoe Creek.	17,203.99	6962.36
87	Upper Horseshoe Creek.	32,293.72	13,069.09
88	Roaring Fork	18,931.02	7661.28
89	Cottonwood Creek	27,533.27	11,142.56
90	Eggleston Creek.	29,157.58	11,799.91
91	Bear Creek	28,246.64	11,431.26
92	North Laramie River.	7656.39	3098.50
93	Claude Irvine Creek.	26,980.75	10,918.96
94	Owen Creek	5346.26	2163.60
95	Dry Laramie River.	10,346.45	4187.15
96	Luman Creek.	22,034.13	8917.09
TOTAL FOR LARAMIE MOUNTAINS		437,733.28	177,148.23
SHERMAN MOUNTAINS			
68	Telephone Creek.	4527.416	1832.220
69	Lodgepole Creek.	20,487.901	8291.340
70	Crow Creek	30,775.613	12,454.720
TOTAL FOR SHERMAN MOUNTAINS		55,790.930	22,578.280

Category Information		
Biodiversity Unit	acres	hectares
MEDICINE BOW MOUNTAINS		
27 S. Fork Lake Creek	5832.45	2360.36
28 North Cedar Creek	6084.66	2462.43
29 Rankin Creek	10,233.94	4141.62
30 Pass Creek	14,987.04	6065.17
31 South Cedar Creek	7071.53	2861.81
32 Lower North Brush Creek	12,443.31	5035.74
33 Upper North Brush Creek	13,925.86	5635.72
34 South Brush Creek	15,367.92	6219.31
35 Lower Brush Creek	9807.62	3969.09
36 North Cottonwood Creek	7045.83	2851.41
37 Middle French Creek	14,312.20	5792.07
38 Upper South French Creek	14,983.53	6063.75
39 Lower South French Creek	8314.87	3364.98
40 Mullen Creek	22,514.86	9111.64
41 Cottonwood Creek	9999.49	4046.74
42 Platte River	25,181.76	10,190.92
43 Pelton Creek	23,496.96	9509.09
44 Lower Douglas Creek	14,134.05	5719.97
45 Mowberg Creek	7086.58	2867.90
46 Lake Creek	11,585.18	4688.46
47 Muddy Creek	7086.26	2867.77
48 Middle Douglas Creek	11,526.84	4664.85
49 Devils Gate Creek	7192.69	2910.84
50 Upper Douglas Creek	13,421.63	5431.66
51 Boswell Creek	11,578.61	4685.80
52 Bear Creek	15,382.20	6225.09
53 Lake Owen Creek	22,281.35	9017.14
54 Johns Creek	12,389.35	5013.90
55 Buckeye Creek	8133.12	3291.43
56 South Fork	9786.12	3960.39
57 Middle Fork	19,793.82	8010.45
58 North Fork	31,003.37	12,546.89
59 Mill Creek	7696.55	3114.75
60 Fourmile Creek	11,366.40	4599.92
61 North Rock Creek	24,024.72	9722.67
62 South Rock Creek	19,541.66	7908.40
63 West Medicine Bow River	9275.34	3753.68
64 Upper Medicine Bow River	8765.70	3547.43
65 Lower Medicine Bow River	10,706.84	4333.00
66 East Medicine Bow River	9858.35	3989.62
67 Wagonhound Creek	7292.79	2951.35
TOTAL FOR MEDICINE BOW MOUNTAINS	**532,513.37**	**215,505.21**

Category Information		
Biodiversity Unit	acres	hectares
SIERRA MADRE MOUNTAINS		
1 Savery Creek	14,866.45	6016.37
2 Dirtyman Creek	7685.85	3110.42
3 Big Sandstone Creek.	28,016.17	11,337.99
4 Little Sandstone Creek	16,157.42	6538.82
5 Big Gulch.	7856.20	3179.36
6 E. Sweetwater Gulch.	2196.15	888.77
7 Lower Battle Creek	17,456.65	7064.61
8 Cottonwood Creek	10,132.78	4100.68
9 Roaring Fork Little Snake.	12,225.94	4947.77
10 North Fork Little Snake.	31,135.14	12,600.22
11 Upper Battle Creek	20,212.58	8179.92
12 West Fork Battle Creek	14,153.54	5727.86
13 Jack Creek	15,020.17	6078.58
14 North Spring Creek	16,579.97	6709.82
15 South Spring Creek	11,466.18	4640.30
16 Cow Creek.	13,038.75	5276.71
17 N. Fork Encampment River	15,060.32	6094.83
18 South Fork Miner Creek	14,191.22	5743.11
19 Hog Park Creek	12,487.22	5053.51
20 Encampment River Canyon.	13,326.82	5393.29
21 Billie Creek	8415.81	3405.83
22 E. Fork Encampment River	12,805.04	5182.13
23 Beaver Creek	12,948.81	5240.31
24 Middle Fork Big Creek.	20,273.27	8204.48
25 Bear Creek	6312.27	2554.54
26 South Fork Big Creek	8282.89	3352.04
TOTAL FOR SIERRA MADRE MOUNTAINS	362,303.63	146,622.27

TABLE AP2.4 5th and 6th level watersheds within Biodiversity Areas

SIERRA MADRE

SIERRA MADRE NORTHWEST BIOLOGICAL DIVERSITY ANALYSIS AREA (BDA)

5TH	5th Name	USGS CODE 6th	6th Name	BDU	
SM 1	Savery Creek	SMW 1.1	N. Fork Savery Creek	1	Savery Creek
		SMW 1.2	E. Fork Savery Creek	1	
		SMW 1.3	Dirtyman Creek	2	Dirtyman Creek
		SMW 1.4	Hell Canyon	2	
		SMW 1.5	Big Sandstone Creek	3	Big Sandstone Creek
SM 5	Jack Creek	SME 5.1	Jack Creek	13	Jack Creek
		SME 5.2	Little Jack Creek	13	
SM 6	Spring Creek	SME 6.1	North Spring Creek	14	North Spring Creek
		SME 6.2	South Spring Creek	15	South Spring Creek
		SME 6.3	Centennial Creek	15	
SM 7	Cow Creek	SME 7.1	Calf Creek	16	Cow Creek
		SME 7.2	Cow Creek	16	

TABLE AP2.4 contd.

SIERRA MADRE SOUTHWEST BIOLOGICAL DIVERSITY ANALYSIS AREA (BDA)

SM 1	Savery Creek	SMW 1.6	Little Sandstone	4	Little Sandstone Creek
		SMW 1.7	Big Gulch	5	Big Gulch
SM 4	Cottonwood Creek	SMW 4.3	E.Sweetwater Gulch	6	E. Sweetwater Gulch
		SMW 4.4	Tree Culture Gulch	6	
SM 2	Battle Creek	SMW 2.1	West Fork Battle Creek	12	W. Fork Battle Creek
		SMW 2.2	Upper Battle Creek	11	Upper Battle Creek
		SMW 2.3	Lower Battle Creek	7	Lower Battle Creek
SM 4	Cottonwood Creek	SMW 4.1	Cottonwood Creek	8	Cottonwood Creek
		SMW 4.2	Spring Creek	8	
		SMW 4.5	Road Gulch	8	
SM 3	Little Snake R.	SMW 3.1	Roaring Fork Little Snake River	9	Roaring Fork Little Snake River
		SMW 3.2	N. Fork Little Snake R.	10	N. Fork Little Snake River
		SMW 3.3	Upper Middle Fk. Little Snake River	10	
		SMW 3.4	Lower Middle Fk. Little Snake River	10	

TABLE AP2.4 contd.

SIERRA MADRE - ENCAMPMENT RIVER BIODIVERSITY ANALYSIS AREA				
SME 8 Encampment River	SME 8.1	N. Fork Encampment R.	17	N. Fork Encampment R.
	SME 8.2	S. Fork Miner Creek	18	S. Fork Miner Creek
	SME 8.3	Soldier Creek	18	
	SME 8.4	Encampment River Canyon	20	Encampment River Can.
	SME 8.6	Upper Encampment River	20	
	SME 8.5	Hog Park Creek	19	Hog Park Creek
	SME 8.7	E.Fork Encampment River	22	E. Fork Encampment R.
	SME 8.8	Billie Creek	21	Billie Creek
	SME 8.9	Dunkard Creek	21	
SIERRA MADRE - SOUTHEAST BIOLOGICAL DIVERSITY ANALYSIS AREA				
SM 9 Beaver Creek	SME 9.1	Beaver Creek	23	Beaver Creek
	SME 9.2	Little Beaver Creek	23	
	SME 9.3	Indian Creek	23	
	SME 9.4	Dufunny Creek	23	
SM 10 Big Creek	SM 10.4	Middle Fork Big Creek	24	Middle Fork Big Creek
	SM 10.1	Bear Creek	25	Bear Creek
	SM 10.2	Henry Creek	25	

TABLE AP2.4 contd.

		SM 10.3	Spring Creek	26	S. Fork Big Creek
		SM 10.5	South Fork Big Creek	26	
		SM 10.6	Lower Big Creek	26	

SNOWY RANGE NORTH - WEST BIOLOGICAL DIVERSITY ANALYSIS AREA (Part of Brush Creek District)

5TH	**5th Name**	**6th**	**6th Name**		
SRNW 1	Dry Creek	SRNW 1.1	Dry Creek	27	S. Fork Lake Creek
		SRNW 1.2	S. Fork Lake Creek	27	
		SRNW 1.3	Buck Springs Draw	27	
SRNW 2	Cedar Creek	SRNW 2.1	N. Cedar Creek	28	N. Cedar Creek
		SRNW 2.2	S. Cedar Creek	31	S. Cedar Creek
SRNW 3	Pass Creek	SRNW 3.3	Middle Pass Creek	29	Rankin Creek
		SRNW 3.4	Lee Creek	29	
		SRNW 3.5	Rankin Creek	29	
		SRNW 3.8	Lower Pass Creek	29	
		SRNW 3.9	Oberg Creek	29	
		SRNW 3.1	Upper Pass Creek	30	Pass Creek
		SRNW 3.2	E. Fork Pass Creek	30	
		SRNW 3.6	Finn Creek	30	
		SRNW 3.7	Little Pass Creek	30	

TABLE AP2.4 contd.

SRNW 7	Brush Creek	SRNW 7.1	North Brush Creek	32	Lower North Brush Creek
				33	Upper North Brush Creek
		SRNW 7.2	South Brush Creek	34	South Brush Creek
		SRNW 7.3	Barrett Creek	35	Lower Brush Creek
		SRNW 7.4	Lower Brush Creek	35	
		SRNW 7.5	Beaver Creek	35	
SRNW 8	N.Cottonwood Cr	SRNW 8.1	N. Cottonwood Creek	36	N. Cottonwood Creek
		SRNW 8.2	Corral Creek	36	
		SRNW 8.3	Moores Creek	36	
		SRNW 8.4	School Creek	36	
SRNW 9	French Creek	SRNW 9.1	N. & Middle French Crks.	37	Middle French Creek
		SRNW 9.2	S. French Creek	38	Upper South French Creek
				39	Lower South French Creek
		SRNW 9.3	Lower French Creek	39	

SNOWY RANGE NORTH - EAST BIOLOGICAL DIVERSITY ANALYSIS AREA (Parts of Brush Creek and Laramie Dist.

5TH	**5th Name**	**6th**	**6th Name**		
SRNE 4	Bow River	SRNE 4.1	Medicine Bow River	63	West Medicine Bow River
				64	Upper Medicine Bow River
				65	Lower Medicine Bow River

TABLE AP2.4 contd.

				66	East Medicine Bow River
		SRNE 4.2	Wagonhound Creek	67	Wagonhound Creek
SRNE 5	Foote Creek	SRNE 5.1	Foote Creek	61	Rock Creek
SRNE 6	Rock Creek	SRNE 6.1	Rock Creek	61	North Rock Creek
				62	South Rock Creek
		SRNE 6.2	Threemile Creek	61	North Rock Creek
SRNE 11	Fourmile Cr	SRNE 11.1	Dutton Creek	60	Fourmile Creek
		SRNE 11.2	Cooper Creek	60	
		SRNE 11.3	Fourmile Creek	60	

SNOWY RANGE NORTH - EAST CENTRAL BIOLOGICAL DIVERSITY ANALYSIS AREA

SRNE 12	Little Laramie	SRNE 12.1	Mill Creek	59	Mill Creek
		SRNE 12.2a	Ward Gulch	59	
		SRNE 12.5	Lower Little Laramie River	59	
		SRNE 12.3	North Fork	58	North Fork
		(SRNE 12.2	Middle Fork)		(Composite name)

TABLE AP2.4 contd.

		SRNE	12.2b Middle Fork	57	Middle Fork
		SRNE	12.4 South Fork*	56	South Fork

Note: SRNE 12.4 (South Fork) will be divided by 7th level watershed so that the part near Albany will be included with Snowy Range North and the part that drains the SW part of Sheep Mountain will be included with Snowy Range South.

SNOWY RANGE SOUTH - WILDERNESS AREAS BIOLOGICAL DIVERSITY ANALYSIS AREA Laramie District

SRS 10	Savage Run	SRS	10.1	Mullen Creek (BCD)	38	Mullen Creek
		SRS	10.2	Bear Gulch (BCD)	38	
		SRS	10.3	Savage Run	38	
		SRS	10.4	Cottonwood Creek	39	Cottonwood Creek
		SRS	10.5	Boat Creek	39	
SRS 15	N. Platte R.	SRS	15.1	Lower N. Platte River	40	Platte River
		SRS	15.2	Elkhorn Creek	40	
		SRS	15.3	Middle N. Platte River	40	
		SRS	15.4	Upper N. Platte River	40	
		SRS	15.5	Walbright Creek	40	

TABLE AP2.4 contd.

SNOWY RANGE SOUTH - SOUTH CENTRAL BIOLOGICAL DIVERSITY ANALYSIS AREA Laramie District				
SRS 14	Douglas Creek	SRS 14.5	Pelton Creek	41 Pelton Creek
		SRS 14.8	Lower Douglas Creek	42 Lower Douglas Creek
		SRS 14.6	Middle Douglas Cr.	43 Mowberg Creek (Mowberg Creek)
		SRS 14.4	Lake Creek	44 Lake Creek
		SRS 14.3	Muddy Creek	45 Muddy Creek
		SRS 14.2	Middle Douglas Creek (Keystone)	46 Middle Douglas Creek
		SRS 4.7	Devils Gate Creek	47 Devils Gate Creek
		SRS 14.1	Upper Douglas Creek	48 Upper Douglas Creek (Rob Roy)
SNOWY RANGE SOUTH - SOUTHEAST BIOLOGICAL DIVERSITY ANALYSIS AREA Laramie District				
SRNE 12	Little Laramie	SRNE 12.4	South Fork*	53 Buckeye Creek
SRS 12	Little Laramie	SRS 12.2c	Buckeye Creek	53
SRS 13	Lower Laramie	SRS 13.1	Johns Creek	52 John's Creek

TABLE AP2.4 contd.

SRS 16	Laramie R.	SRS 16.1	Lake Owen Creek	51	Lake Owen Creek
		SRS 16.2	Bear Creek	50	Bear Creek
		SRS 16.3	Boswell Creek	49	Boswell Creek
		SRS 16.4	Johnson Creek	49	

SHERMAN HILLS BIOLOGICAL DIVERSITY ANALYSIS AREA

	5TH	**5th Name**	**6th**	**6th Name**		
SH 1	Telephone Creek		SH 1.1	Telephone Creek	62	Telephone Creek
			SH 1.2	Government Gully	62	
			SH 1.3	Harney Creek	62	
SH 2	Horse Creek		SH 2.1	Horse Creek	63	Lodgepole Creek
SH 3	Lodgepole Creek		SH 3.1	North Lodgepole Creek	63	
			SH 3.2	Middle Lodgepole Creek	63	
			SH 3.3	South Lodgepole Creek	63	
SH 4	Crow Creek		SH 4.1	N. & S. Branch Crow Creek	64	Crow Creek
			SH 4.2	Brush Creek	64	
			SH 4.3	Middle Crow Creek	64	
			SH 4.4	South Crow Creek	64	
SH 5	Lone Tree Creek		SH 5.1	Lone Tree Creek	64	
SH 6	Dale Creek		SH6.1	Dale Creek	64	

TABLE AP2.4 contd.

LARAMIE MOUNTAINS NORTH - NORTHWESTERN BIOLOGICAL DIVERSITY ANALYSIS AREA

5TH	5th Name	6th	6th Name		
LMN 1	Bates Creek	LMN 1.1	Bates Creek	66	Bates Creek
LMN 2	Deer Creek	LMN 2.1	West Fork Deer Creek (part)	65	West Fork Deer Creek
		LMN 2.2	Lower Deer Creek	65	
		LNM 2.3	Upper Deer Creek	67	Upper Deer Creek
		LMN 2.1	Upper Deer Creek (part)	67	West Fork Deer Creek
LMN 3	Box Elder Creek	LMN 3.1	Virden Creek	68	Virden Creek
		LMN 3.2	Snowshoe Creek	68	
		LMN 3.3	Box Elder Creek	69	Box Elder Creek
		LMN 3.4	East Box Elder Creek	70	East Box Elder Creek
LMN 4	Little Medicine	LMN 4.1	N. Fork Little Medicine Bow River	73	Little Medicine Bow River
		LMN 4.2	S. Fork Little Medicine Bow R.	73	
LMN 5	LaPrele Creek	LMN 5.1	Perry Creek	71	Standing Rock Creek
		LMN 5.2	Standing Rock Creek	71	
LMN 5.3	Meadow Creek	LNN 5.3	Meadow Creek	72	Meadow Creek

TABLE AP2.4 contd.

LMN 7 Sheep Creek	LMN 7.1 Sheep Creek	74	
LARAMIE MOUNTAINS NORTH - NORTH CENTRAL BIOLOGICAL DIVERSITY ANALYSIS AREA			
LMN 6 Latham Creek	LMN 6.1 Latham Creek	76	Latham Creek
LMN 8 LaBonte Creek	LMN 8.1 West Fork LaBonte Creek (Lower Part)	77	West Fork LaBonte Cr
	LMN 8.1 West Fork LaBonte Creek (Upper Part)	75	Rocky Ford Creek
	LMN 8.2 LaBonte Creek (Most)	78	LaBonte Creek
LARAMIE MOUNTAINS SOUTH - SOUTHCENTRAL BIOLOGICAL DIVERSITY ANALYSIS AREA			
LMS 9 Horseshoe Creek	LMS 9.1 Upper Horseshoe Creek	81	Upper Horseshoe Cr
	LMS 9.2 Roaring Fork	82	Roaring Fork Cr.
	LMS 9.3 Lower Horseshoe Creek	80	Lower Horseshoe Cr.
	LMS 9.4 North Horseshoe Creek	80	
LMN 8 LaBonte Creek	LMN 8.2 LaBonte Creek (part)	79	Mill Creek
LMS 10 Cottonwood Creek	LMS 10.1 Cottonwood Creek	81	Claude Irvine Creek
	LMS 10.2 Crow Creek	81	

TABLE AP2.4 concl.

LARAMIE MOUNTAINS SOUTH - SOUTHWESTERN BIOLOGICAL DIVERSITY ANALYSIS AREA

5TH	5th Name	6th	6th Name		
LMS 11	N. Laramie River	LMS 11.1	Eggleston Creek	84	Eggleston Creek
		LMS 11.3	Cow Creek	84	
		LMS 11.4	N. Laramie River(part)	84	
		LMS 11.2	Bear Creek	85	Bear Creek
		LMS 11.4	N. Laramie River(part)	86	N. Laramie River

LARAMIE MOUNTAINS SOUTH - SOUTHERN BIOLOGICAL DIVERSITY ANALYSIS AREA

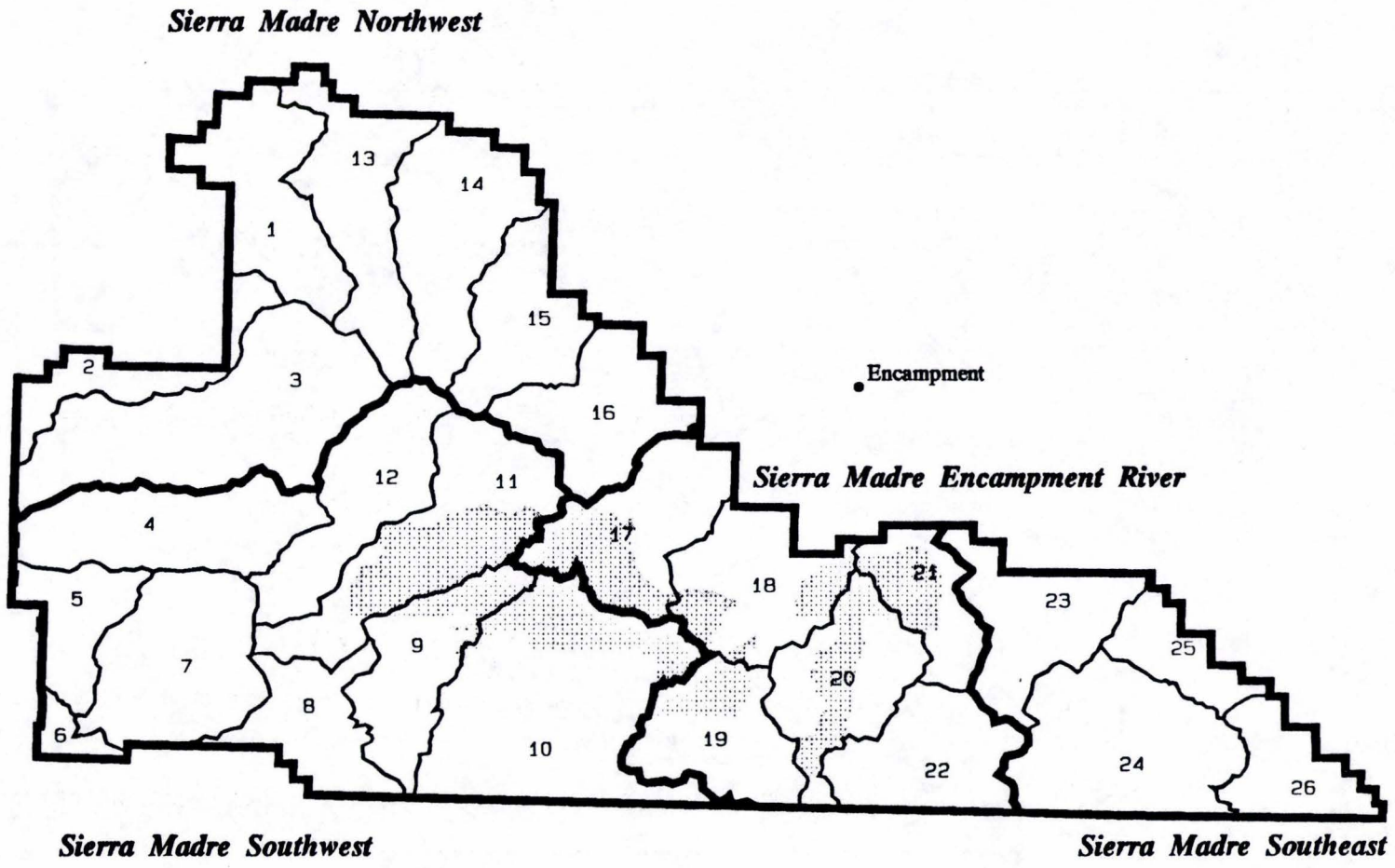
LMS 11	N.Laramie River	LMS 11.5	Sieboldt Creek	88	Owen Creek
		LMS 11.6	Owen Creek	88	
		LMS 11.7	Claude Irvine Creek	87	Claude Irvice Creek
		LMS 11.8	Fish Creek	87	
LMS 12	Dry Laramie River	LMS 12.1	Dry Laramie River	89	Dry Laramie River
LMS 13	Luman Creek	LMS 13.1	Marble Quarry Creek	90	Luman Creek
		LMS 13.2	Luman Creek	90	
		LMS 13.3	Rabbit Creek	90	
		LMS 13.4	Collins Creek	90	
		LMS 13.5	Ashley Creek	90	
		LMS 13.6	Laramie River	90	

MEDICINE BOW NATIONAL FOREST

Biodiversity Unit and Area Map

SIERRA MADRES

FIGURE AP2.1a



LEGEND

1 Savery Creek
2 Dirtyman Creek
3 Big Sandstone Creek
4 Little Sandstone Creek
5 Big Gulch
6 E. Sweetwater Gulch
7 Lower Battle Creek
8 Cottonwood Creek
9 Roaring Fork Little Snake
10 North Fork Little Snake
11 Upper Battle Creek
12 West Fork Battle Creek
13 Jack Creek
14 North Spring Creek
15 South Spring Creek
16 Cow Creek
17 N. Fork Encampment River
18 South Fork Miner Creek
19 Hog Park Creek
20 Encampment River Canyon
21 Billie Creek
22 E. Fork Encampment River
23 Beaver Creek
24 Middle Fork Big Creek
25 Bear Creek
26 South Fork Big Creek

Biodiversity Unit Boundary

Biodiversity Area Boundary

Wilderness

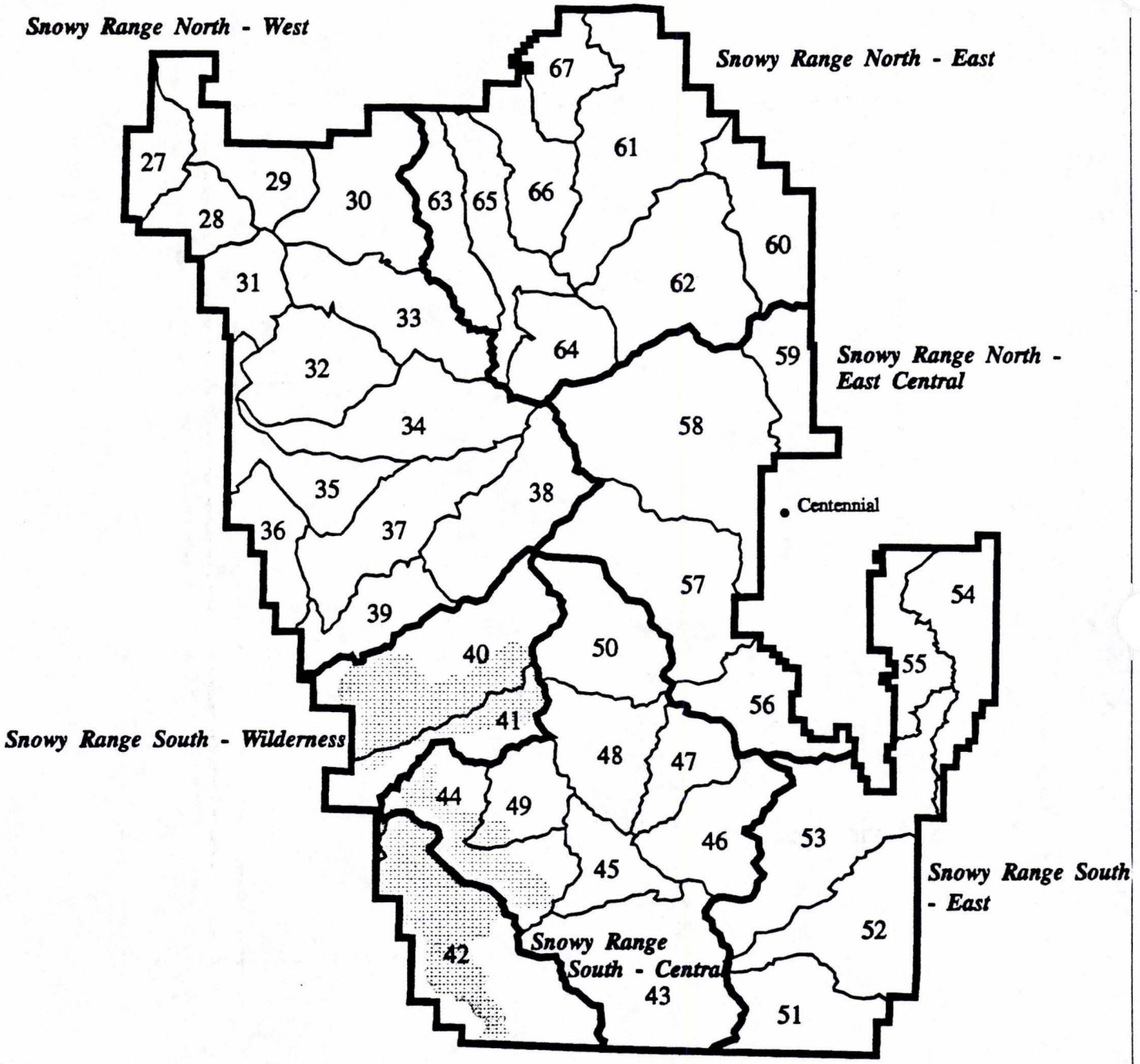
Scale 1 to 375,000

Created by CLT for JVA, 01/20/95, bdu_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Biodiversity Units and Areas

FIGURE AP2.1b



Created by CLT for JVA, 01/20/95, bdu snowy.aml

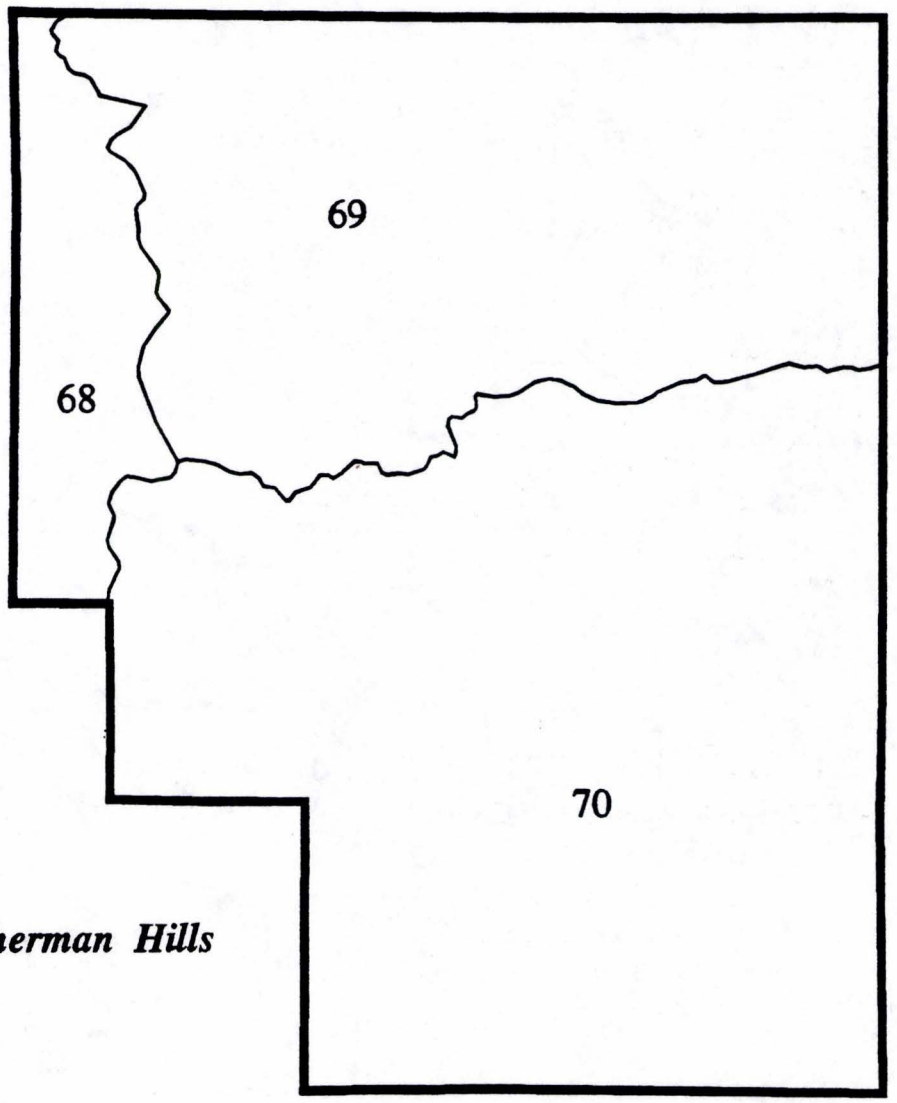
27	S. Fork Lake Creek	39	Lower South French Creek	51	Boswell Creek	63	West Medicine Bow River
28	North Cedar Creek	40	Mullen Creek	52	Bear Creek	64	Upper Medicine Bow River
29	Rankin Creek	41	Cottonwood Creek	53	Lake Owen Creek	65	Lower Medicine Bow River
30	Pass Creek	42	Platte River	54	Johns Creek	66	East Medicine Bow River
31	South Cedar Creek	43	Pelton Creek	55	Buckeye Creek	67	Wagonhound Creek
32	Lower North Brush Creek	44	Lower Douglas Creek	56	South Fork		
33	Upper North Brush Creek	45	Mowberg Creek	57	Middle Fork		Biodiversity Unit Boundary
34	South Brush Creek	46	Lake Creek	58	North Fork		Biodiversity Area Boundary
35	Lower Brush Creek	47	Muddy Creek	59	Mill Creek		Wilderness
36	North Cottonwood Creek	48	Middle Douglas Creek	60	Fourmile Creek		
37	Middle French Creek	49	Devils Gate Creek	61	North Rock Creek		
38	Upper South French Creek	50	Upper Douglas Creek	62	South Rock Creek		

Scale 1 to 375,000

MEDICINE BOW NATIONAL FOREST — SHERMAN MOUNTAINS

Biodiversity Units and Areas

FIGURE AP2.1c



Created by CLT for JVA, 01/23/95, bdu sherman.aml

LEGEND

68 Telephone Creek
69 Lodgepole Creek
70 Crow Creek

Biodiversity Unit Boundary

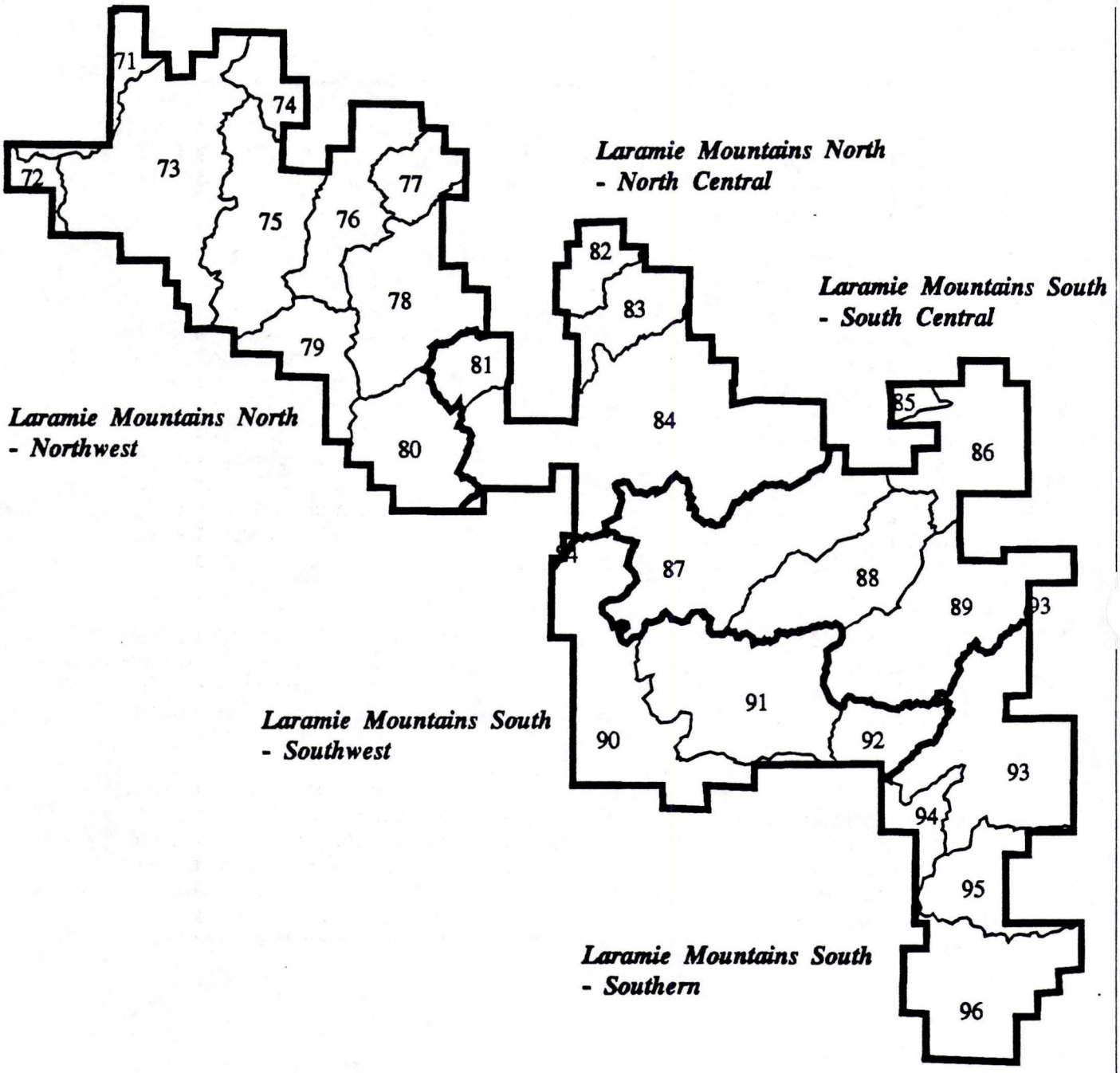
Biodiversity Area Boundary

Scale 1 to 125,000

MEDICINE BOW NATIONAL FOREST — LARAMIE RANGE

Biodiversity Units and Areas

FIGURE AP2.1d



Created by CLT for JVA, 01/23/95, bdu laramie.aml

LEGEND

71 West Fork Deer Creek
72 Bates Creek
73 Upper Deer Creek
74 Virden Creek
75 Box Elder Creek
76 East Box Elder Creek
77 Standing Rock Creek
78 Meadow Creek
79 Little Medicine Bow River
80 Sheep Creek
81 Rocky Ford Creek
82 Latham Creek
83 West Fork LaBonte Creek
84 LaBonte Creek
84 LaBonte Creek
85 Mill Creek
86 Lower Horseshoe Creek
87 Upper Horseshoe Creek
88 Roaring Fork
89 Cottonwood Creek
90 Eggleston Creek
91 Bear Creek
92 North Laramie River
93 Claude Irvine Creek
93 Claude Irvine Creek
94 Owen Creek
95 Dry Laramie River
96 Luman Creek

Biodiversity Unit Boundary

Biodiversity Area Boundary

Scale 1 to 425,000

APPENDIX 3

CLIMATIC DIVERSITY OF THE MEDICINE BOW NATIONAL FOREST

Climate descriptions are based on temperature and precipitation records from 32 stations shown in Table AP3.1 and Figure AP3.1. These data provide a regional context for the temperature and precipitation regimes on the Medicine Bow National Forest and they permit analysis of differences in climate among the four mountain areas.

A list of the stations, station elevations and years of record, organized by drainage basin and elevation, is in Table AP3.1. Most data was obtained from the Wyoming Water Resources Center (University of Wyoming) or the Colorado Climate Center (Colorado State University) in Fort Collins. Data for Glacier Lakes came from the Rocky Mountain Forest and Range Experiment Station in Fort Collins. The Coon Creek and Blackhall Mountain data is from the Coon Creek Project data base at the Hayden Ranger District, Encampment, Wyoming. The Squaw Peaks Ranch precipitation information is from private records kept by Mr. Art Fawcett of Esterbrook, Wyoming. Note that the years of record differ among stations. Several records (Pole Mountain, Rand, Coon Creek, Blackhall Mountain, Glacier Lakes and Hohnholz Ranch) are less than 10 years in length.

Annual total precipitation, estimated snowfall and mean annual temperature, organized by drainage basin and increasing precipitation is in Table AP3.2. Monthly temperature and precipitation amounts, used to make the climatograms, are in Tables AP3.3 and AP3.4.

Climatograms showing the pattern of monthly annual precipitation (bars) and monthly mean temperature (lines) for the 32 stations are in Figure AP3.2. The horizontal line is drawn at the 40 degree Fahrenheit level (left side y-axis) and the two-inch precipitation level (right-side Y-axis). This permits visual scaling of months which have less than two inches of precipitation or monthly temperatures above or below forty degrees Fahrenheit.

There are four general precipitation patterns.

U-Shaped Flat Unimodal Bimodal

1. U-shaped
   (Glacier Lakes, Blackhall Mountain, Coon Creek, Steamboat Springs, and Columbine). This pattern shows the heavy winter snowfall from October to May. Precipitation ranges from about 2 to 6 inches per month. Assuming a ratio of 10 inches of snow to 1 inch of precipitation, this approximates 20 to 60 inches of snow. June, July and August have about 2 inches of precipitation or less. This pattern is typical of the western side of the Continental Divide which receives most moisture from storms originating in the southwest or northwest. Moisture from the storms originating in the Gulf of Mexico or from the Arizona Monsoon have little signal in these climatograms.

2. Flat
   (Foxpark, Centennial, Red Feather Lakes, Encampment, Baggs, Hayden, Fraser, Walden). Less than two inches of precipitation falls each month for this group of stations, except for Fraser Experimental Forest, which receives slightly more than two inches in April-May and for fall and winter months. Precipitation is rather evenly distributed throughout the year. Temperature interacts with the low precipitation amounts, causing soil drought conditions during much of the year for all stations except Fraser. Fraser is just east of the Continental Divide near Winter Park Ski Area in Central Colorado. The Fraser weather data is included to compare the pattern and amounts because much of the research on lodgepole pine and spruce-fir forest harvest and regeneration applied to the Medicine Bow National Forest has been done at the Fraser Experimental Forest.

3. Unimodal
   (Double-4, Sybille Research Station, Horse Creek, Wheatland, Medicine Bow, Shirley Basin). This is the typical Front Range weather pattern characteristic of areas north of the Palmer Divide in Colorado which are not

affected by the Arizona Monsoon (July-August) or fall storms from the Pacific Northwest. Moisture from the Gulf of Mexico falling mainly as snow or rain in the spring months (March-May) provides the largest monthly precipitation amounts. At most stations this exceeds two inches for some or all of those months. Precipitation becomes progressively less through the summer and fall months.

4. Bimodal

(Elk Mountain Ranch, Saratoga, Hohnholz Ranch, Guernsey, Chugwater, Cheyenne, Douglas, Casper, Glenrock, Rand, Laramie and Pole Mountain). Two kinds of bimodal patterns occur. One is demonstrated by Casper and Saratoga where there is a, smaller pulse of moisture in the fall (Sept-Nov) after the spring moisture. Rand has the spring moisture pattern with additional moisture from July convectional storms from the Arizona Monsoon. The Arizona Monsoon signal (July-August) is very strong southward from the Palmer Divide of Colorado and along the Front Range (von Ahlefeldt, 1992). The Rand station has a weak signal typical of that pattern as does Laramie. Walden has a very weak signal. The Arizona monsoon does not appear to reach into the Sierra Madre, Medicine Bow Mountains. Pole Mountain has a weak signal in July and August. Precipitaton is less than two inches per month at most of these stations.

The change in precipitation pattern from southwest to northeast can be seen in Figure AP3.1. The seasonality of precipitation is modified by elevation which affects the amount of precipitation. Temperature is the other major limiting climatic factor. Temperature patterns are the same for all stations, but the amount of degrees differs. Wind is another important climate factor, especially on N-S trending ridges (Encampment River Canyon area, portions of the Continental Divide in the Sierra Madre, Rock Creek Ridge and the Medicine Bow Peak area, the summit on Pole Mountain and the southern end of the Laramie Mountains. Low humidity and dry winter conditions with constant wind results in plant communities of spruce-fir krumholz, limber pine or shrublands.

Figures AP3.2 and AP3.3 and Table AP3.4 present estimates of lapse rates for temperature and precipitation. In their simplest form, lapse rates express how much temperature or precipitation change occurs between two points as a function of elevation difference. Lapse rates are shown as linear functions if only two points are known. Actual temperature and precipitation differences are not likely linear, but lapse rates provide a useful comparative estimate. Temperature lapse rates are 2.5 to 3.6 degrees Fahrenheit

per thousand feet for the six areas analyzed. The slopes of all the lines are approximately the same, and temperature decreases as elevation increases.

The precipitation lapse rates are more varied. Cheyenne receives more precipitation than Pole Mountain, so the lapse rate line has a negative slope. All other lines show increasing precipitation with elevation. The steepest line is from Centennial (CENT) to Glacier Lakes (GLEES). The lapse rate is 13.3 inches (slightly better than a foot) per thousand feet. Thus in the 10 linear miles from Centennial to GLEES, there is a very sharp precipitation gradient equal to about 10 feet of snow annually.

These data illustrate several points:

1. The Sierra Madre is much more similar climatically to the Park Range on the Routt National Forest than to the Medicine Bow Mountains.

2. The seasonality of precipitation on the Fraser Experimental Forest is different than all areas of the Medicine Bow National Forest. Application of research from Fraser ecosystems should be applied to the Medicine Bow forests with awareness of characteristics of Medicine Bow climate patterns.

3. The Snowy Range of the Medicine Bow Mountains has high snowfall compared to all the rest of the Medicine Bow NF administrative area, but the area receiving the snow is small and the precipitation gradients radiating out from Medicine Bow Peaks are very steep

4. The Sherman Mountains and Laramie Mountains are climatically similar to other areas of the Front Range north of Denver, but drier.

5. Major climate differences, especially with regard to precipitation amount and seasonality exist within the Medicine Bow National Forest.

6. Different air masses contribute to the precipitation differences.

TABLE AP3.1 Station elevations and years of record.

STATION	ELEVATION	YEARS OF RECORD	TOTAL YEARS
UPPER N. PLATTE RIVER			
Medicine Bow, WY	6120	1948-1993	45
Saratoga, WY	6790	1948-1993	43
Shirley Basin, WY	7170	1977-1993	15
Laramie, WY	7200	1948-1993	45
Elk Mountain Ranch, WY	7265	1948-1993	44
Encampment, WY	7360	1948-1993	45
Hohnholz Ranch, CO	7760	1985-1992	8
Walden, CO	8120	1938-1992	55
Centennial, WY	8140	1948-1993	37
Pole Mountain, WY	8530	1951-1958	8
Rand, CO	8630	1988-1992	5
Coon Creek, WY	8800	1988-1993	8
Foxpark, WY	9065	1948-1979	27
Blackhall Mtn., WY	10280	1984-1992	8
Glacier Lakes (GLEES)	10800	1988-1993	6
LOWER N. PLATTE RIVER			
Guernsey Dam, WY	4500	1949-1980	32
Wheatland, WY	4638	1913-1967	55
Horse Creek, WY	4700	1955-1979	24
Douglas, WY	4800	1915-1962	42
Glenrock, WY	4948	1964-1987	23
Casper, WY	5195	1949-1979	30
Chugwater, WY	5282	1915-1993	78
Sybille Res. Sta., WY	6100	1964-1993	29
Cheyenne, WY	6126	1915-1993	79
Squaw Peaks Ranch, WY	6150	1976-1990	14
Double Four Ranch, WY	6200	1948-1993	42
S. PLATTE RIVER, COLORADO			
Red Feather Lakes, CO	8170	1941-1990	50
Fraser Exp. Forest CO	9000	1935-1985	50
COLORADO RIVER, COLORADO			
Baggs, WY	6247	1979-1993	14
Hayden, CO	6380	1931-1992	63
Steamboat Springs, CO	6760	1931-1992	63
Columbine, CO	8700	1931-1949	19

TABLE AP3.2 Annual total precipitation, estimated snowfall, and mean annual temperature.

Station	Precip	Snowfall*	Temp
UPPER N. PLATTE RIVER			
Saratoga, WY	9.51	37	42.7
Shirley Basin, WY	9.56	24	39.6
Walden, CO	10.22	37	36.8
Medicine Bow, WY	10.28	38	41.9
Laramie, WY	11.53	38	42.2
Elk Mountain Ranch, WY	12.29	55	41.3
Pole Mountain, WY	12.69	41	37.8
Encampment, WY	14.28	64	41.2
Centennial, WY	14.30	64	40.5
Hohnholz Ranch, CO	14.86	65	38.3
Rand, CO	15.84	60	36.7
Foxpark, WY	16.13	115	34.1
Coon Creek, WY	30.52	185	32.7
Blackhall Mtn., WY	33.20	227	31.6
Glacier Lakes, WY (Glees)	49.81	341	12.7
LOWER N. PLATTE RIVER			
Wheatland, WY	10.08	43	49.8
Casper, WY	12.59	48	47.3
Douglas, WY	13.89	43	45.8
Double Four Ranch, WY	14.08	46	42.9
Guernsey Dam, WY	14.29	47	48.7
Cheyenne, WY	15.18	58	45.4
Horse Creek, WY	15.33	54	45.5
Glenrock, WY	15.23	58	42.4
Sybille Res. Sta., WY	16.11	58	46.0
Chugwater, WY	16.49	60	46.4
Squaw Peaks Ranch, WY	20.75	96	42.9**
S. PLATTE, RIVER, COLORADO			
Red Feather Lakes, CO	16.68	62	39.4
Fraser Exp. Forest, CO	26.88	136	33.4
COLORADO RIVER, COLORADO			
Baggs, WY	10.84	39	41.7
Hayden, CO	16.22	81	42.4
Steamboat Springs, CO	23.40	136	39.0
Columbine, CO	24.93	146	27.3

* Snowfall is estimated by adding monthly mean precipitation for Nov.-April times 10. This appears to underestimate snowfall, when compared to the few stations that have snowfall records. The Nov-April estimate was used for consistency and so that each station would have a value.

** Temperature values are from Double-4 Ranch

TABLE AP3.3 MONTHLY AND ANNUAL PRECIPITATION

TOTAL PPT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM
BAGGS 1979-1993	0.54	0.49	0.54	0.75	1.42	0.80	1.50	0.90	1.09	1.48	0.86	0.75	10.84
BLACKHALL MTN 1984-1992	2.48	3.36	4.37	3.70	2.57	2.06	2.36	1.38	2.08	2.42	3.48	2.94	33.20
CASPER 1949-1979	0.54	0.51	0.91	1.63	2.43	1.63	1.07	0.67	0.95	1.02	0.74	0.49	12.59
CENTENNIAL 1948-1993	1.07	0.83	1.07	1.21	1.61	1.48	1.63	1.26	1.16	0.82	1.02	1.15	14.30
CHEYENNE 1915 - 1993	0.40	0.80	1.19	2.33	2.45	1.57	1.94	1.25	1.50	0.97	0.43	0.61	15.18
CHUGWATER 1915-1993	0.53	0.58	1.06	1.90	2.78	2.28	1.83	1.35	1.20	1.02	1.31	0.65	16.49
COLUMBINE 1931-1949	2.73	2.65	2.54	2.53	2.03	1.33	1.49	1.75	1.98	1.77	1.67	2.46	24.93
COON CREEK 1984-1992	2.57	2.90	3.80	3.02	2.45	1.98	2.12	1.18	2.16	2.10	3.54	2.70	30.52
DOUBLE 4 RANCH 1948-1993	0.41	0.42	0.95	1.54	2.80	2.36	1.83	1.24	1.15	0.73	0.73	0.52	14.08
DOUGLAS 1915-1993	0.34	0.46	0.51	2.10	2.05	1.14	1.49	0.47	0.71	1.57	0.48	0.45	13.89
ELK MTN 1948-1993	0.71	0.70	1.04	1.40	1.71	1.29	1.00	0.90	1.03	0.93	0.95	0.69	12.29
ENCAMPMENT 1948 - 1993	0.79	0.80	1.25	1.57	1.73	1.32	1.31	1.39	1.19	1.26	1.05	0.89	14.28
FOXPARK 1948-1979	1.51	1.11	1.37	1.38	1.45	1.57	1.53	1.60	1.23	0.97	1.13	1.28	16.13
FRASER (E) '35-85	2.15	1.78	1.83	2.38	2.15	1.88	1.97	2.18	2.65	2.49	2.62	2.80	26.88
GLEES 1990-1994	5.20	5.38	5.80	5.95	2.91	2.68	2.30	1.49	1.81	2.37	4.31	4.62	49.81
GLENROCK 1964-1987	0.61	0.67	1.14	1.85	2.75	2.23	1.41	0.85	1.14	1.08	0.89	0.61	15.23
GUERNSEY DAM 1948-1980	1.09	0.34	0.81	1.60	2.69	2.32	1.60	1.16	1.10	0.72	0.46	0.40	14.29
HAYDEN 1931-1992	1.33	1.16	1.30	1.49	1.46	1.23	1.36	1.33	1.29	1.51	1.26	1.50	16.22
HOHNHOLZ RANCH 1985-1992	0.75	1.08	1.39	1.40	1.70	1.73	1.75	1.32	0.91	0.91	1.03	0.89	14.86
HORSE CREEK 1955-1979	0.60	0.59	1.10	1.85	2.39	2.21	1.99	1.20	1.23	0.92	0.68	0.57	15.22
LARAMIE 1948-1993	0.45	0.46	0.78	1.14	1.50	1.31	1.72	1.24	0.90	0.76	0.54	0.45	11.53
MEDICINE BOW 1948-1993	0.47	0.50	0.72	1.08	1.58	1.18	1.22	0.83	0.92	0.79	0.54	0.45	10.28
POLE MTN 1951-1958	0.41	0.36	1.06	1.06	1.30	1.33	1.67	1.68	0.25	0.59	0.50	0.66	12.69
RAND 1988-1992	0.53	0.75	1.66	1.18	1.69	1.38	2.26	1.50	1.55	1.51	1.10	0.73	15.84
RED FEATHER LKS 1941-1990	0.62	0.73	1.28	2.06	2.16	1.70	2.29	1.83	1.29	1.06	0.92	0.60	16.68
SARATOGA 1948-1993	0.47	0.44	0.77	0.91	1.33	0.92	0.98	0.91	0.84	0.96	0.58	0.48	9.51
SHIRLEY BASIN 1977-1993	0.41	0.38	0.36	0.73	1.56	1.45	1.71	1.04	0.83	0.55	0.32	0.23	9.56
SQAW PEAKS RANCH 1976-1990	0.79	1.13	2.18	2.57	3.60	2.08	1.98	1.01	1.08	1.38	1.77	1.18	20.75
STEAMBT SPRGS 1931-1992	2.40	2.16	2.15	2.27	2.11	1.54	1.49	1.52	1.55	1.80	2.03	2.52	23.40
SYBILLE RES.STA 1964-1993	0.65	0.61	1.11	1.79	2.48	2.38	1.69	1.31	1.31	1.11	0.90	0.66	16.11
WALDEN 1938-1992	0.52	0.47	0.70	0.83	1.19	1.04	1.26	1.14	1.06	0.80	0.65	0.56	10.22
WHEATLAND 1913-1967	0.20	0.37	0.56	2.55	1.95	1.05	0.80	0.65	0.61	0.71	0.22	0.41	10.08

TABLE AP3.4 MEAN MONTHLY AND MEAN ANNUAL TEMPERATURES

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVG
BAGGS 1979-1993	17.0	20.7	32.8	43.1	50.9	60.4	66.6	64.5	55.7	43.9	29.3	19.1	41.7
BLACKHALL MTN. 1984-1992	10.0	13.0	19.8	28.0	37.8	49.0	54.5	53.9	44.7	33.7	18.5	15.8	31.6
CASPER 1949-1979	25.3	30.2	35.1	44.2	54.2	63.9	71.8	69.9	59.5	48.8	35.8	29.2	47.3
CENTENNIAL 1948-1993	22.5	24.5	28.3	36.8	45.9	55.1	61.6	59.8	52.3	43.0	30.0	23.8	40.5
CHEYENNE 1915 - 1993	28.2	25.7	34.1	40.9	50.0	60.5	63.8	65.9	57.5	46.0	36.7	30.2	45.4
CHUGWATER 1915-1993	27.0	29.8	34.6	43.5	52.7	62.1	69.0	67.4	58.1	47.5	35.7	28.9	46.4
COLUMBINE 1931-1949	16.6	15.1	19.0	36.8	43.8	59.6	58.5	56.*	49.*	38.8	28.8	20.1	36.8
COON CREEK 1984-1992	12.1	15.5	22.5	31.1	39.9	48.5	54.3	52.8	44.8	35.8	21.9	12.9	32.7
DOUBLE 4 RANCH 1948-1993	23.4	26.8	31.6	40.6	49.5	58.3	64.9	63.2	54.2	44.5	32.9	25.5	42.9
DOUGLAS 1915-1993	26.9	25.2	35.5	43.8	53.8	63.6	71.4	68.1	59.1	47.4	36.1	19.1	45.8
ELK MTN 1948-1993	22.5	24.7	29.5	38.1	47.7	56.9	63.3	61.3	53.2	43.9	30.9	24.3	41.3
ENCAMPMENT 1948 - 1993	21.5	23.9	29.2	38.8	48.4	56.6	63.1	61.9	53.7	43.9	31.1	23.6	41.2
FOXPARK 1948-1979	15.8	17.8	21.5	30.5	40.0	49.2	54.8	52.9	46.3	37.3	24.5	18.1	34.1
FRASER (EST)'35-85	12.2	15.1	20.5	33.8	41.3	50.8	59.0	51.9	44.6	35.2	19.8	16.2	33.4
GLEES 1990-1994	12.9	14.7	19.4	25.9	36.7	45.7	49.6	50.5	56.3	31.6	16.3	12.7	31.0
GLENROCK 1964-1987	23.2	25.3	30.6	38.8	48.6	57.8	65.9	63.7	54.2	43.8	31.6	24.8	42.4
GUERNSEY DAM 1948-1980	20.8	33.4	36.4	46.0	56.9	67.0	73.5	72.0	63.9	50.0	35.6	28.9	48.7
HAYDEN 1931-1992	17.2	21.7	30.3	42.4	51.7	60.1	66.5	64.7	56.3	45.4	31.5	20.7	42.4
HOHNHOLZ RANCH 1985-1992	20.0	22.6	29.4	37.4	44.8	54.6	58.8	56.7	49.0	39.7	27.6	18,8	38.3
HORSE CREEK 1955-1979	26.7	29.0	32.2	41.0	51.8	61.1	67.8	66.4	57.2	48.0	35.4	29.1	45.5
LARAMIE 1948-1993	21.4	24.2	29.0	42.9	47.9	57.7	64.3	62.5	54.0	43.4	30.4	23.8	42.2
MEDICINE BOW 1948-1993	21.1	24.2	30.0	40.3	49.8	59.1	65.0	62.7	53.8	43.4	30.3	23.0	41.9
POLE MTN 1951-1958	21.0	23.6	23.6	33.7	44.1	54.8	61.1	59.2	53.0	42.8	28.9	22.7	37.8
RAND 1988-1992	17.2	20.7	28.8	36.4	44.5	51.9	55.7	54.7	49.7	39.3	25.2	16.1	36.7
RED FEATHER LKS 1941-1990	22.7	24.2	27.6	35.7	44.7	54.1	60.6	59.0	51.2	42.5	30.6	24.6	39.4
SARATOGA 1948-1993	20.9	24.6	31.0	40.7	50.4	59.7	66.0	63.9	55.1	44.3	31.6	23.5	42.7
SHIRLEY BASIN 1977-1993	18.4	20.3	29.3	36.8	48.0	57.8	63.7	62.1	52.7	41.8	27.0	17.8	39.6
SQAW PEAKS RANCH 1976-1990**	23.4	26.8	31.6	40.6	49.5	58.3	64.9	63.2	54.2	44.5	32.9	25.5	42.9
STEAMBT SPRGS 1931-1992	14.8	19.5	28.1	39.0	48.2	55.4	61.9	60.4	52.7	42.7	28.7	17.7	39.0
SYBILLE RES.STA 1964-1993	25.9	28.6	34.8	43.4	52.4	62.0	69.2	67.6	58.7	48.0	34.8	26.8	46.0
WALDEN 1938-1992	15.9	18.7	25.3	35.4	44.6	53.5	58.8	56.5	49.0	39.2	26.2	18.7	36.8
WHEATLAND 1913-1967	31.3	29.4	39.7	46.9	57.0	66.3	73.4	70.9	61.7	51.7	42.8	26.3	49.8

* Substituted temperatures: Aug- Sept from Hohnholz Ranch used for Columbine; All temperatures from Doubgle-4 used f0r Sqaw Peaks Ranch. Fraser Temperatures estimated from Alexander et al (1985).

TABLE AP3-5 ELEVATION DIFFERENCES, DISTANCES AND TEMPERATURE AND PRECIPITATION LAPSE RATES FOR PORTIONS OF THE MEDICINE BOW NATIONAL FOREST

	Elev. Diff.	Distance Miles	Ppt. in/1000′	Temp. °F/1000′
SIERRA MADRE MTS.				
Baggs-Blackhall Mtn. 6247′ 10280′	4033′	53	5.5	3.6
Encampment-Blackhall Mtn 7360′ 10280′	2920′	15	6.5	3.3
MEDICINE BOW MTS.				
Saratoga-GLEES 6790′ 10800′	4010′	25	10.0	3.3
Centennial-GLEES 8140′ 10800′	2660′	10	13.3	2.5
SHERMAN MTS.				
Laramie-Pole Mtn. 7200′ 8530′	1330′	10	.87	3.2
Cheyenne-Pole Mtn. 6126′ 8530′	2404′	32	-10.0	2.9

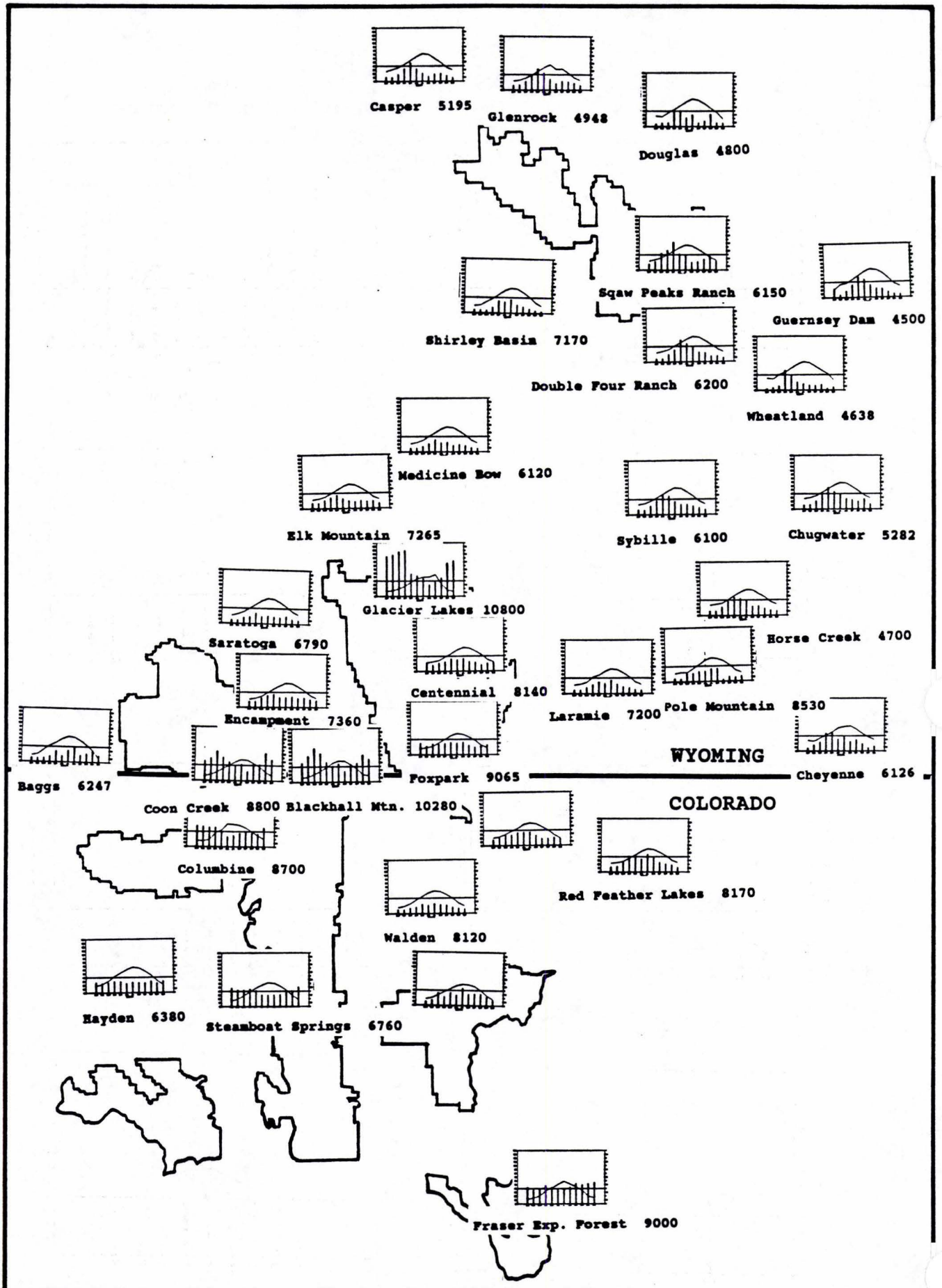
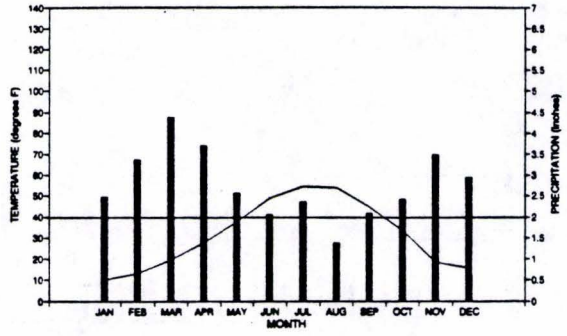
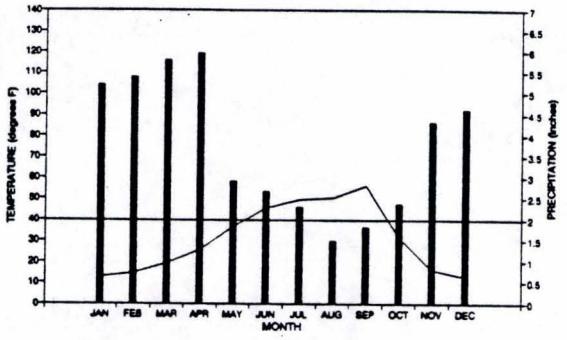


FIGURE AP3.1 Climatic gradients of monthly precipitation and temperature across north central Colorado and southeastern Wyoming.

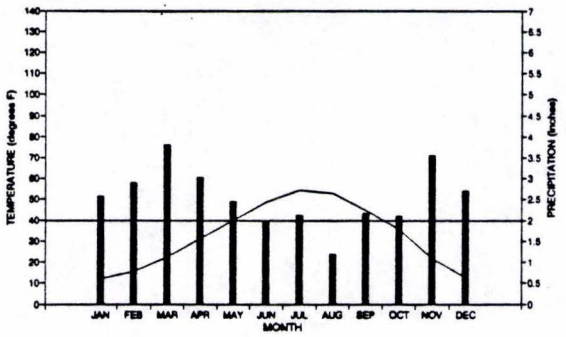
BLACKHALL MOUNTAIN, WY
10280 feet 1984 - 92



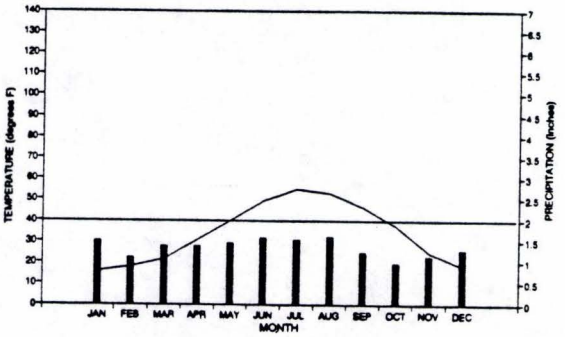
GLACIER LAKES EES, WY
10800 feet 1990 - 94



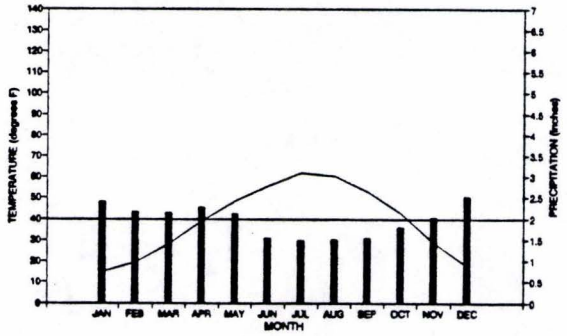
COON CREEK, WY
8800 feet 1984 - 92



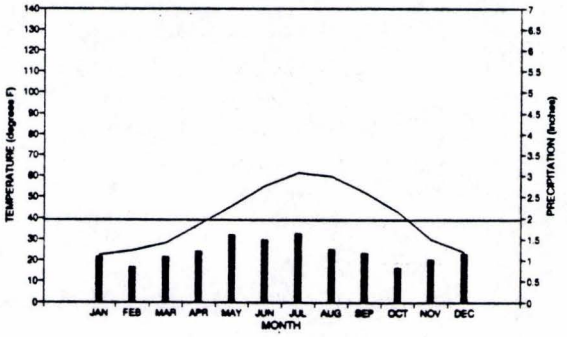
FOXPARK, WY
9065 feet 1948 - 79



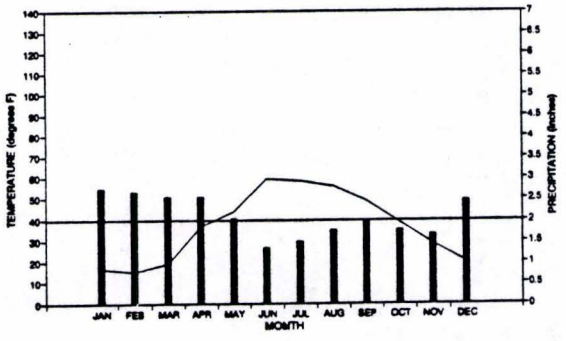
STEAMBOAT SPRINGS, COLORADO
6760 feet 1931 - 92



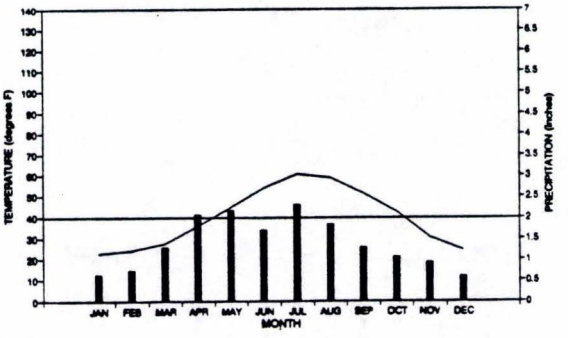
CENTENNIAL, WY
8140 feet 1948 - 93



COLUMBINE, COLORADO
8700 feet 1931 - 49



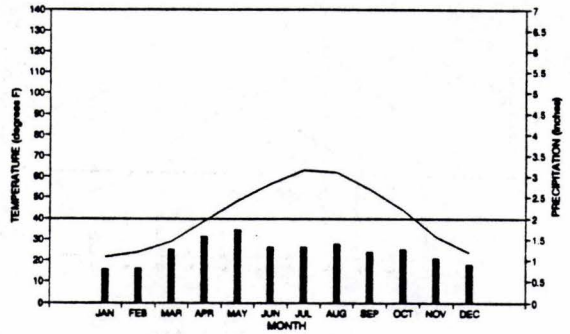
RED FEATHER LAKES, COLORADO
8170 feet 1941 - 90



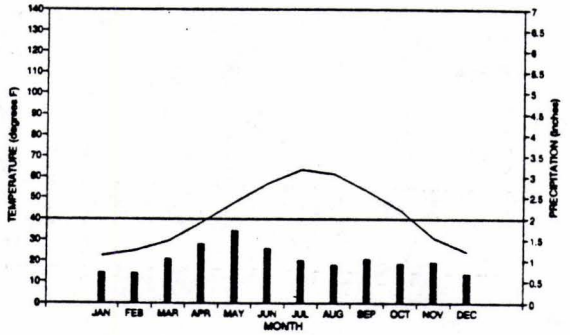
temperature precipitation

FIGURE AP3.2a Climatograms

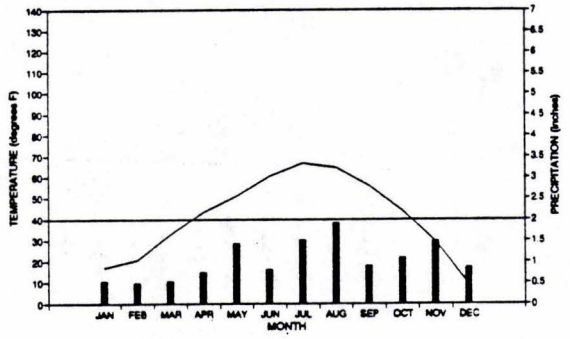
ENCAMPMENT, WY
7360 feet 1948 - 93



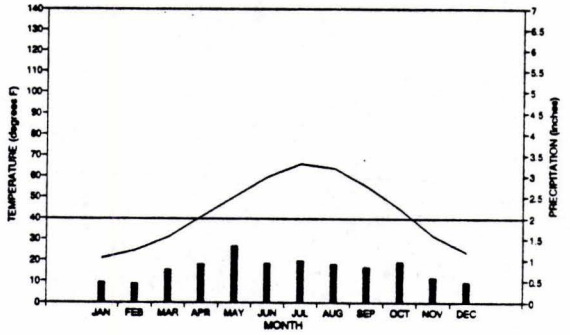
ELK MOUNTAIN RANCH, WY
7265 feet 1948 - 93



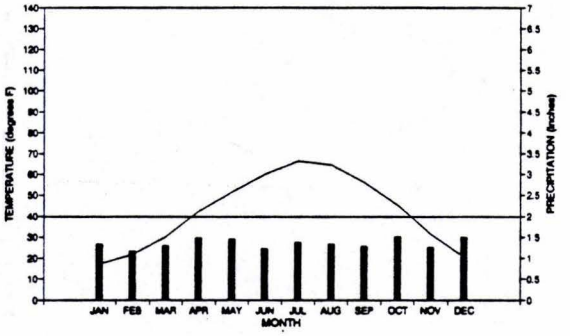
BAGGS, WY
6247 feet 1979 - 93



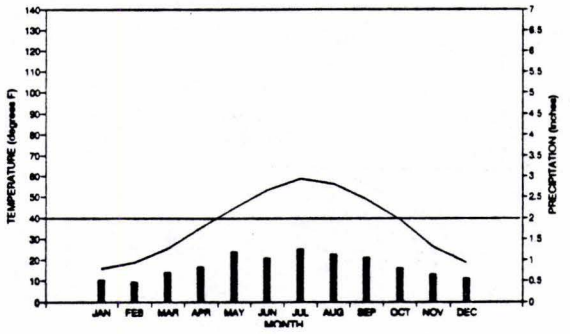
SARATOGA, WY
6790 feet 1948 - 93



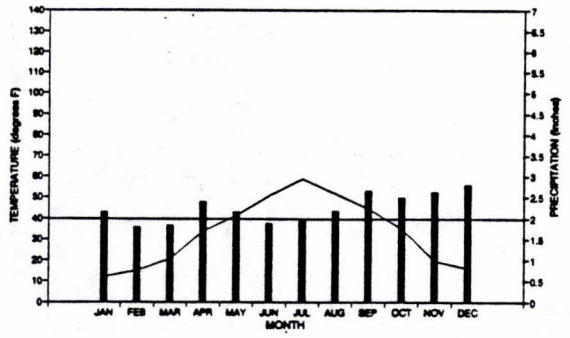
HAYDEN, COLORADO
6380 feet 1931 - 92



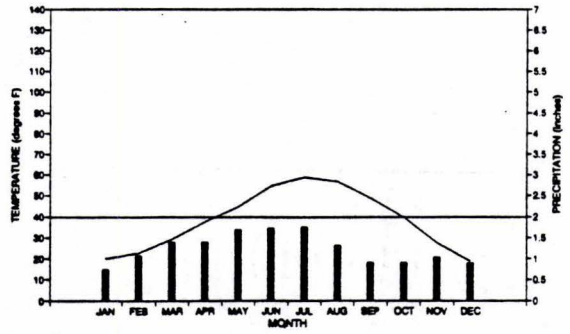
WALDEN, COLORADO
8120 feet 1938 - 92



FRASER EXP. FOREST, COLORADO
9000 feet 1935 - 85



HOHNHOLZ RANCH, COLORADO
7760 feet 1985 - 92



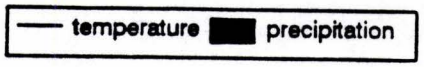
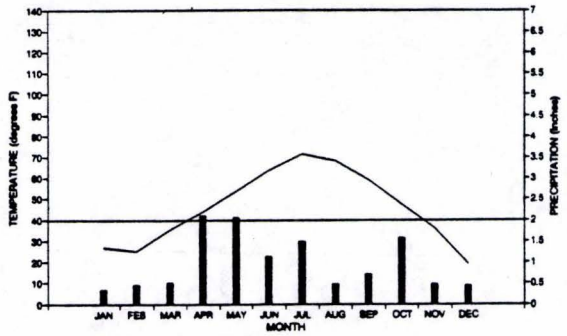
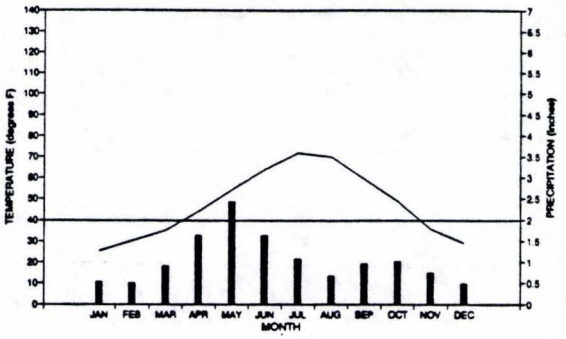


FIGURE AP3.2b Climatograms

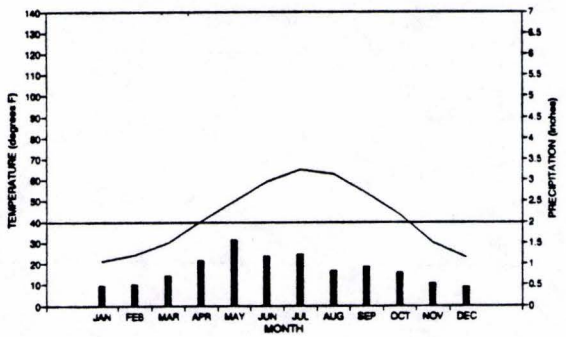
DOUGLAS, WY
4800 feet 1915 - 93



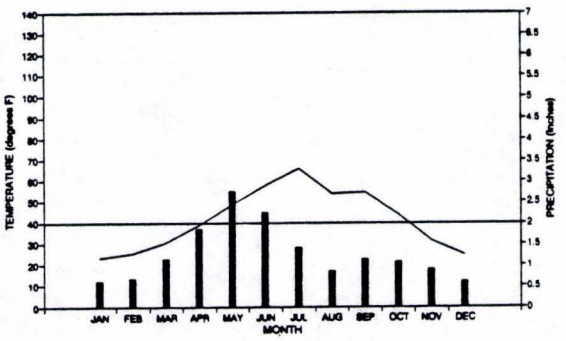
CASPER, WY
5195 feet 1949-79



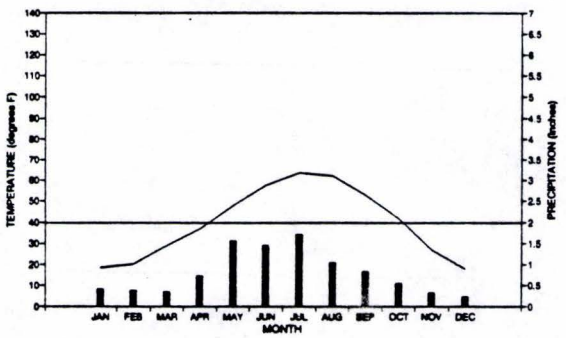
MEDICINE BOW, WY
6120 feet 1948 - 93



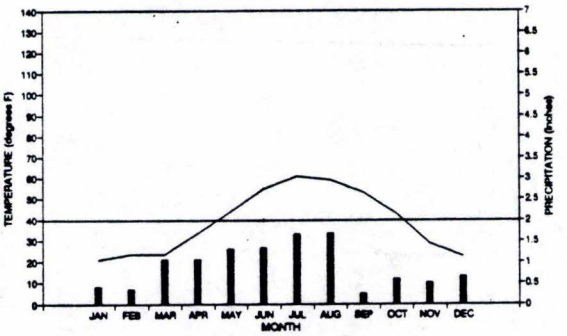
GLENROCK, WY
4948 feet 1964 - 87



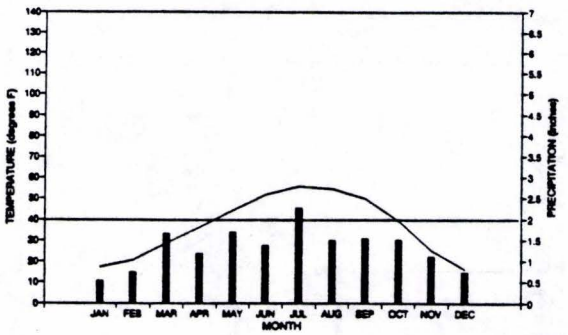
SHIRLEY BASIN, WY
7170 feet 1977 - 93



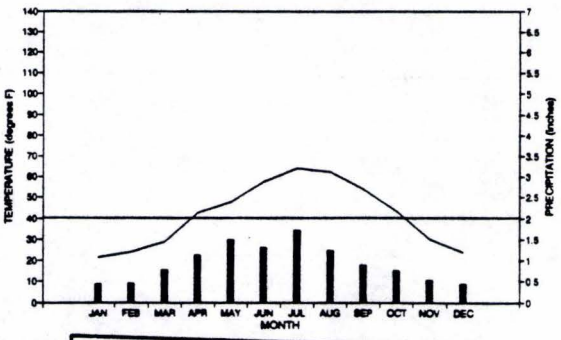
POLE MOUNTAIN, WY
8530 feet 1951 - 58



RAND, COLORADO
8360 feet 1988 - 92



LARAMIE, WY
7200 feet 1948-1993



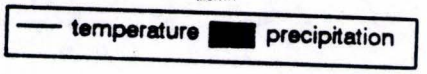
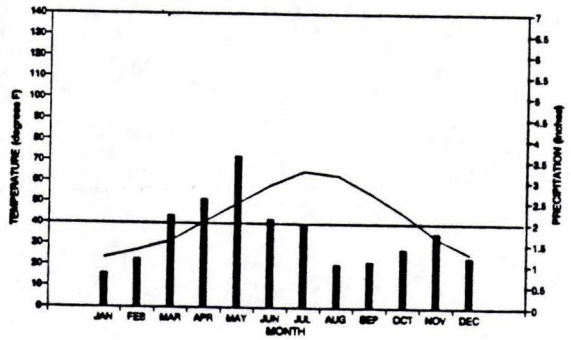
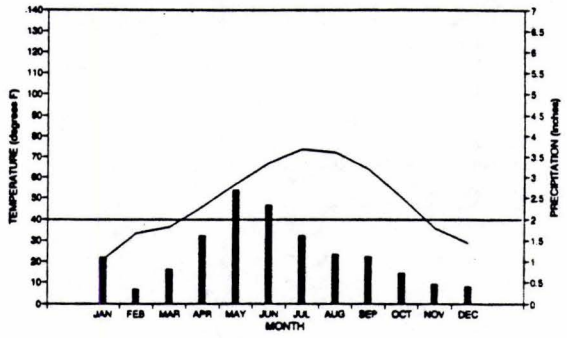


FIGURE AP3.2c Climatograms

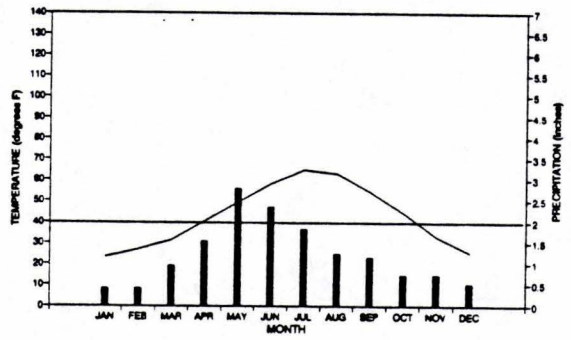
SQAW PEAKS RANCH, WY
6150 feet 1976 - 90



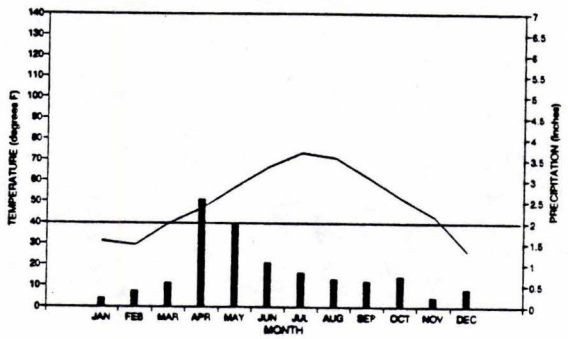
GUERNSEY DAM, WY
4500 feet 1948 - 80



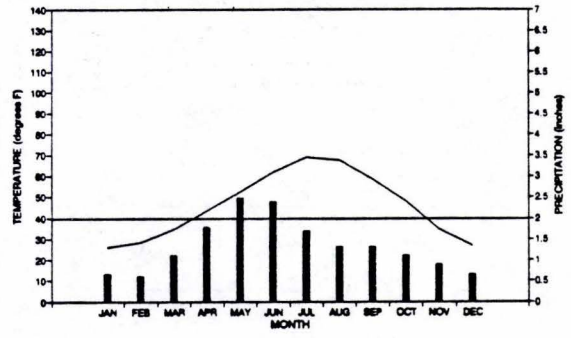
DOUBLE FOUR RANCH, WY
6200 feet 1948 - 93



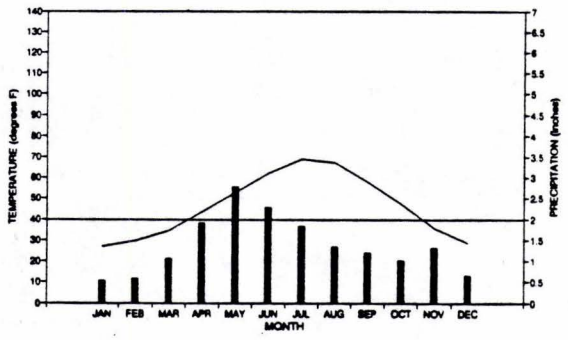
WHEATLAND, WY
4638 feet 1913 - 67



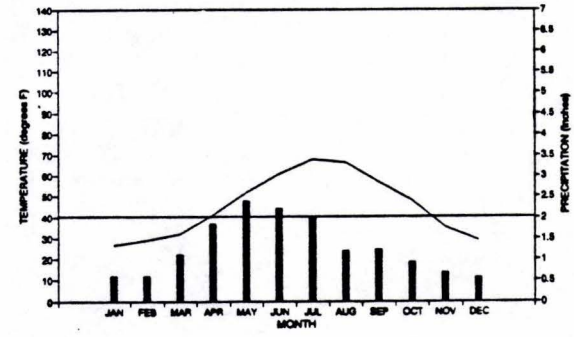
SYBILLE RESEARCH STATION, WY
6100 feet 1964 - 93



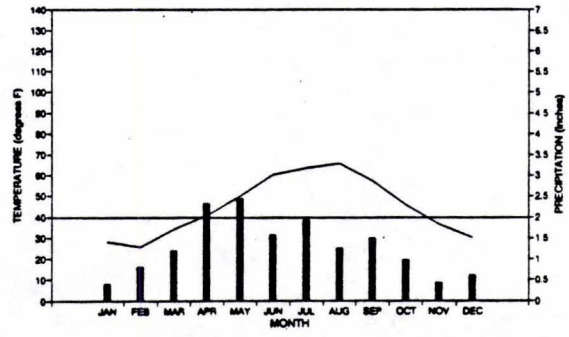
CHUGWATER, WY
5282 feet 1915 - 93



HORSE CREEK, WY
4700 feet 1955 - 79



CHEYENNE, WY
6126 feet 1948 - 93



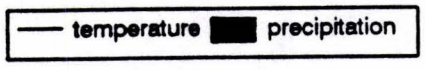


FIGURE AP3.2d Climatograms

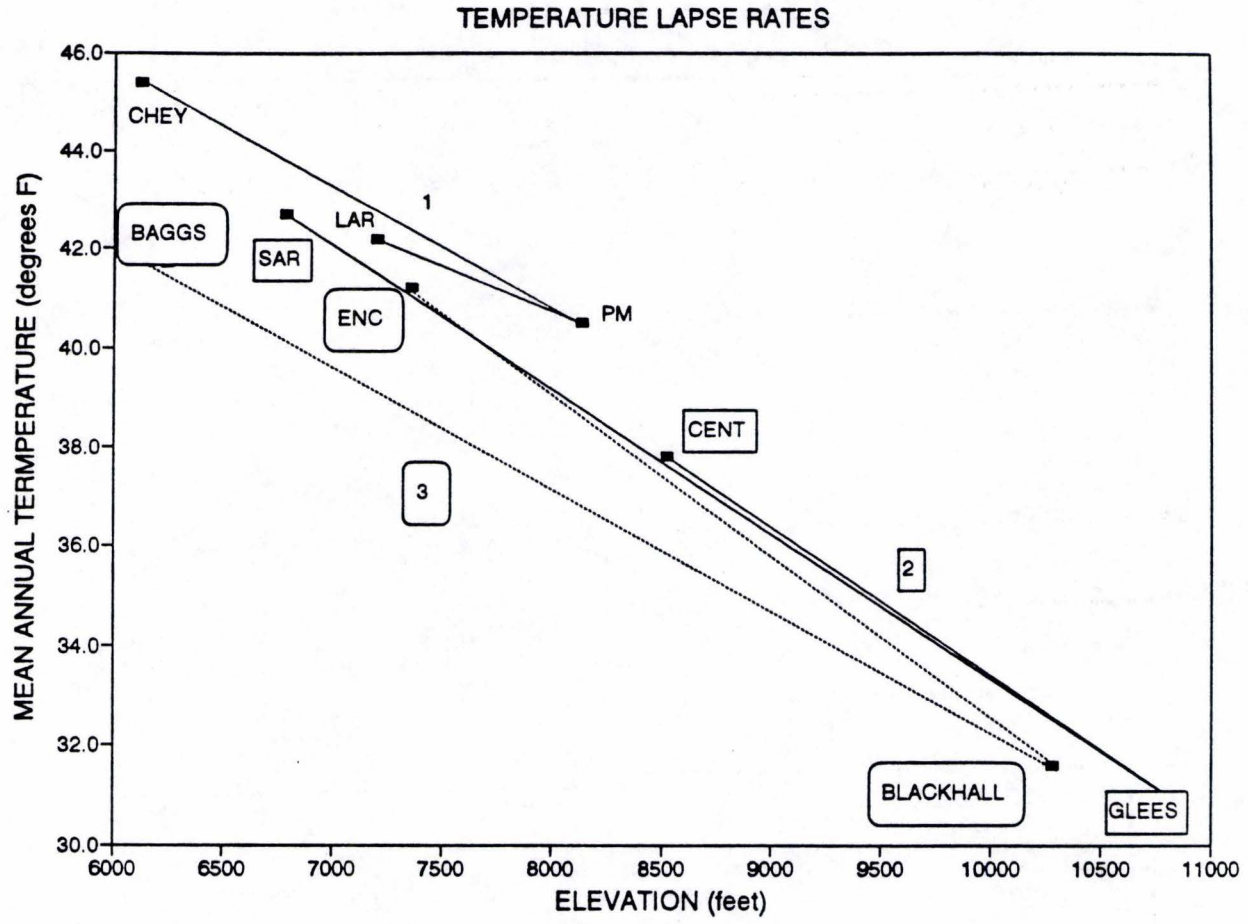


FIGURE AP3.3 Temperature lapse rates: 1. Laramie to Pole Mountain to Cheyenne 2. Encampment to GLEES to Saratoga 3. Baggs to Blackhall Mountain to Encampment. Lapse rates show the average temperature change as a function of elevation. This graph implies that the relationship is linear, which it probably is not.

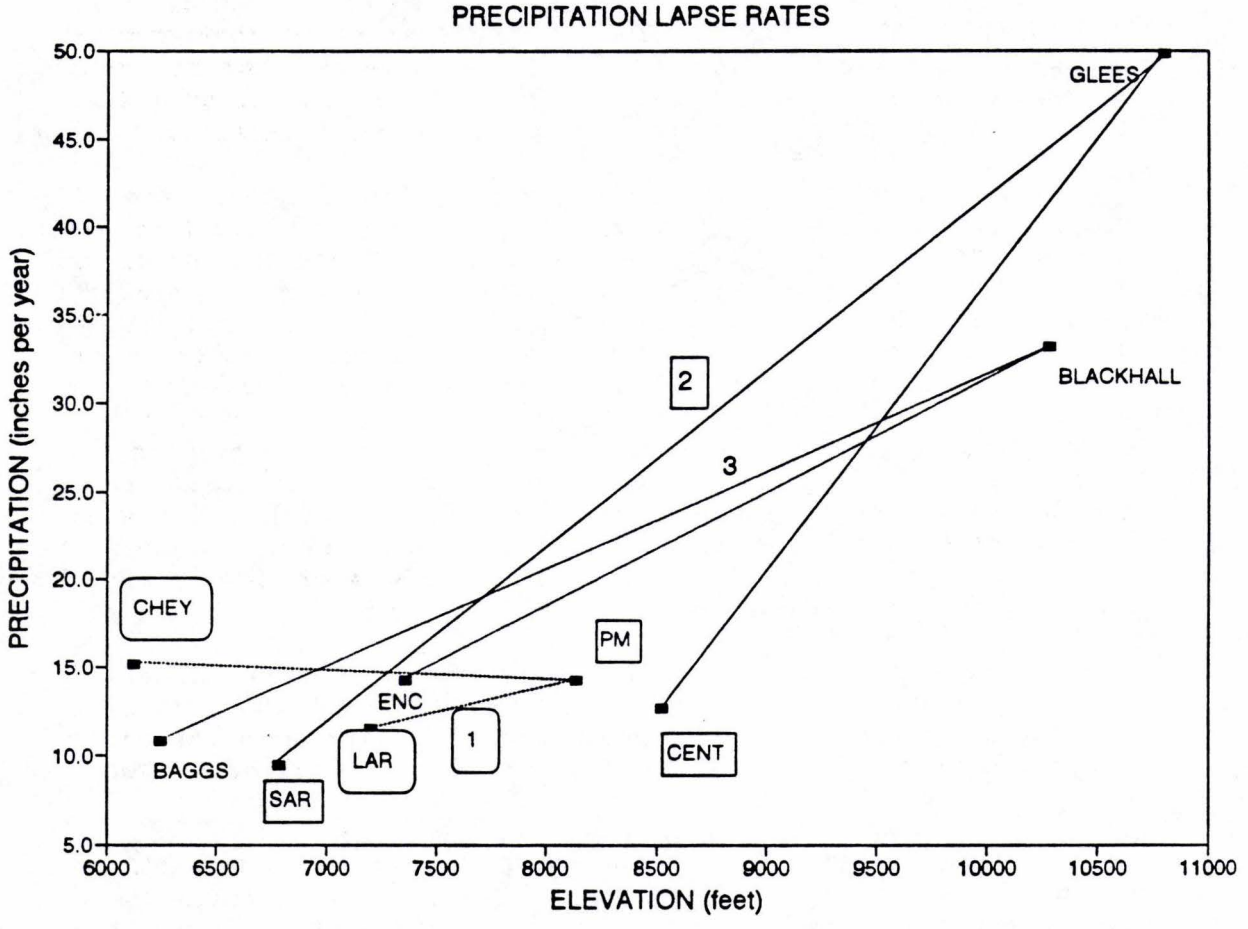


FIGURE AP3.4 Precipitation lapse rates: 1. Laramie to Pole Mountain to Cheyenne 2. Encampment to GLEES to Saratoga 3. Baggs to Blackhall Mountain to Encampment. Lapse rates show the average precipitation change as a function of elevation. This graph implies that the relationship is linear, which it probably is not.

APPENDIX 4

PLANT SPECIES BIOLOGICAL DIVERSITY

A search of literature produced a total of 1162 doeumented plant species for the Medicine Bow National Forest. Most of these are vascular plants, but a few are ferns or other non-vascular species. The Medicine Bow Mountains (Snowy Range) has the most documented species (884), then the Sierra Madre Mountains (749), followed by the Laramie Mountains and the Sherman Mountains.

About two-thirds of the species are forbs. There are 12 species of trees and nearly 100 shrubs. Summaries by life form and mountain range are in Tables A!4.1 and AP4.2. Individual species, grouped by Tree, Shrub, Grass, Forb and Ferns & other non-vascular plants are in Table 4.3 noted by mountain range. This permits a comparison of the distribution of species. There are some major differences among the Sierra Madre Mountains, the Medicine Bow Mountains and the two easternmost areas (Laramie Mountains and Sherman Mountains) reflecting differences in climate, elevation and plant ranges. The Laramie Mountains and Sherman Mountains have species characteristic of the Great Plains and Front Range. High elevations of the Medicine Bow Mountains are a botanic island for species requiring alpine conditions. The southwestern Sierra Madre has many exotic species which favor mild climates.

The following sources were used to compile the documentation matrix of plant species occurrence for the Sierra Madre Mountains, the Medicine Bow Mountains (Snowy Range), the Sherman Mountains (Pole Mountain) and the North Laramie Mountains (Laramie Peaks area).

The documentation matrix (Table AP4.3) includes the PLANTS Database acronym, notation as to occurrence of the species (SM = Sierra Madre; SR = Snowy Range; SH = Sherman Mountains; LP and LR = Northern Laramie mountains), scientific name and common name. LP indicates plants collected in the Ashenfelder Basin area by Aven Nelson in 1895-96; LR indicates species recorded by Judy von Ahlefeldt during the riparian classification study (1991-1992) or by others.

In Table AP4.3, Region 2 Sensitive species (1994) are noted with an asterisk (*) after the location. Species identified for special concern by THE Nature Conservancy are annotated with an plus (+) after the location. USFWS Category 2 species are noted as C2.

Documentation:

SIERRA MADRE MOUNTAINS

Current, F.B. 1984. **The distribution and description of the vegetation of Battle Mountain as explained by abiotic factors.** PhD Dissertation Range Management U. WY

Dorn, R. and Fertig, W. 1994. Personal communication
Fertig, W. 1994. **Wyoming plant species of special concern. Wyoming Natural Diversity Database** Laramie, Wyoming

Fertig, W. 1995. **Wyoming Rare Plant Field Guide.** The Nature Conservancy. Wyoming Natural Diversity Database. Laramie, WY

Jones, G. 1992. **A preliminary classification of riparian vegetation types of the Medicine Bow Range and the Sierra Madre.** The Nature Conservancy. Laramie, WY
Prepared for the Medicine Bow National Forest

Kastning, N. 1990 **A floristic survey of the Park and Sierra Madre Ranges, Colorado and Wyoming.** M.S. Department of Botany
University of Wyoming
(Plant species were annotated by county so it was possible to select species collected in the Sierra Madre mountains in Carbon County, WY.)

Severson, K.E. 1963. **A description and classification, by composition, of the aspen stands in the Sierra Madre Mountains,** Wyoming. Master's Thesis U. WY Laramie, WY

Williams, R.L. 1994. **Plant List for the Sierra Madres** Report by Affiliate of the Rocky Mountain Herbarium Laramie, WY

MEDICINE BOW MOUNTAINS (SNOWY RANGE)

Dorn, R. and Fertig, W. 1994. Personal communication

Nelson, B.E. 1974. **Vascular plants of the Medicine Bow Mountains, Wyoming.** M.S. University of Wyoming

Fertig, W. 1992. **Checklist of the vascular plants of the Medicine Bow Range, Wyoming.** Wyoming Natural Diversity Database, THE Nature Conservancy Laramie, WY

Fertig, W.F. 1993. **Survey of alpine plant species of special concern in the Medicine Bow Peak Special**

Botanical Area. Wyoming Natural Diversity Database. Laramie, WY

Fertig, W. 1994. **Wyoming plant species of special concern.** Wyoming Natural Diversity Database Laramie, Wyoming

Fertig, W. 1995. **Wyoming Rare Plant Field Guide.** The Nature Conservancy. Wyoming Natural Diversity Database. Laramie, WY

Haines, J.A. and C.M. Regan 1994. **Vascular plants of Glees.** In: Musselman, R.C. Technical Editor The Glacier Lakes Ecosystem Experiments Site. USDA Forest Service General Technical Report RM-249

Smith, D.R. 1969. **Vegetation, Soils and their Interrelationships at timberline in the Medicine Bow Mountains, Wyoming** Science Monograph 17 Agricultural Experiment Station U. WY, Laramie

SHERMAN MOUNTAINS

Aslamy, M.N. 1965. **Upland vegetation of the Pole Creek Drainage, Pole Mountain Area, WY.** M.S. University of Wyoming

Call, M.W. 1970. **Beaver pond ecology and beaver-trout relationships in southeastern Wyoming.** PhD Diss. University of Wyoming

Dorn, R. and Fertig, W. 1994. Personal communication.

Fertig, W. 1994. **Wyoming plant species of special concern.** Wyoming Natural Diversity Database Laramie, Wyoming

Fertig, W. 1995. **Wyoming Rare Plant Field Guide.** The Nature Conservancy. Wyoming Natural Diversity Database. Laramie, WY

Holliday, J.N.,Jr. 1965. **Vascular plants of a sedge meadow, Pole Mountain Area, WY** M.S. University of Wyoming

NORTH LARAMIE MOUNTAINS

Dorn, R. and Fertig, W. 1994. Personal communication.

Fertig, W. 1994. **Wyoming plant species of special concern.** Wyoming Natural Diversity Database Laramie, Wyoming

Fertig, W. 1995. **Wyoming Rare Plant Field Guide.** The Nature Conservancy. Wyoming Natural Diversity Database. Laramie, WY

Nelson, A. 1895. **Ashenfelder Basin species list (August).** IN: Jones (1989)

Nelson, A. 1900. **Ashenfelder Basin species list. (July).** IN Jones (1989)

Jones, G. P. 1989. **Report on the Ashenfelder Basin Special Interest Area.** Wyoming Natural Diversity Database For the Medicine Bow National Forest, Laramie, WY

von Ahlefeldt, J.P. 1993. **Laramie Range Riparian Classification project.** Douglas Ranger District. Medicine Bow National Forest Laramie, WY (In progress)

Information on Threatened and Endangered Species and species of Special Concern was obtained from the Wyoming Natural Diversity Database in Laramie, Wyoming. The Natural Diversity Database also provided information on plant species on the Region 2 Sensitive Species list (USFS).

Nomenclature follows **Plants of Wyoming - Alphabetical Listing** USDA SCS (1994); **Plant List of Accepted Nomenclature, Taxonomy and Symbols, Alphabetical Listing Report**, USDA SCS (1992) or the **Wyoming Plant List (1992)** published by the Rocky Mountain Herbarium (University of Wyoming) for species not in the USDA listing.

Acronyms are from:

USDA Soil Conservation Service. 1994. **Plants of Wyoming - Alphabetical Listing** July 7, 1994 National Plant Materials Center Beltsville, MD.

USDA Soil Conservation Service. 1992. **Plant List of Accepted Nomenclature, Taxonomy and Symbols Alphabetical Listing Report.** National Plant Materials Center Beltsville, MD.

Common names were drawn from:

USDA Soil Conservation Service. 1994. **Plants of Wyoming - Alphabetical Listing** July 7, 1994 National Plant Materials Center Beltsville, MD.

Fertig, W. 1994. **Wyoming plant species of special concern.** Wyoming Natural Diversity Database Laramie, Wyoming

INFORMATION ASSESSMENT

The information on flora of the Snowy Range (Medicine Bow Mountains) is the most complete of all the areas because this range has been studied extensively for over a century. Floristic surveys have recently been done in the Sierra Madre mountains. The Sherman Hills and North Laramie Mountains have had the fewest floristic surveys.

The species tally reflects documented species and species which are expected. For the Sierra Madre and Medicine Bow Mountains, the species lists are believed to be mostly complete for a large-scale assessment. Additional work is needed at high elevations and in riparian areas, especially in the Sierra Madre. Surveys of the Laramie Mountains are scheduled in the future by the Rocky Mountain Herbarium as staff time and funding permits. Additional study is needed for the Sherman Mountains.

TABLE AP4.1 SPECIES TOTALS BY LIFE FORM
(Medicine Bow National Forest)

TREES	12
SHRUBS	94
FORBS	814
GRAMINOIDS	216
NON-VASCULAR PLANTS	26
TOTAL	**1162 species of plants**

Table AP4.2 SPECIES RICHNESS BY LIFE FORM FOR MOUNTAIN RANGES

	Sierra Madre	Snowy Range	Sherman Mtns.	Laramie Mtns.
TREES	10	11	10	11
SHRUBS	63	72	37	56
FORBS	538	612	223	234
GRAMINOIDS	128	169	60	93
FERNS & Non-vascular	10	20	10	9
Total	749	884	340	403

TABLE AP4.3 PLANT SPECIES OF THE MEDICINE BOW NATIONAL FOREST

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
						TREES	
SM	SR	SH	LP	Abla	*Abies*	*lasiocarpa*	subalpine fir
SM	SR		LP	Acne2	*Acer*	*negundo*	boxelder
SM	SR	SH	LP	Pien	*Picea*	*engelmannii*	Engelmann's spruce
			LP	Pigl	*Picea*	*glauca*	white spruce
SM	SR	SH		Pipu	*Picea*	*pungens*	blue spruce
SM	SR	SH	LP	Pico	*Pinus*	*contorta*	lodgepole pine
SM	SR	SH	LP	Pifl2	*Pinus*	*flexilis*	limber pine
SM	SR	SH	LP	Pipo	*Pinus*	*ponderosa*	ponderosa pine
SM	SR	SH	LR	Poan3	*Populus*	*angustifolia*	narrowleaf cottonwood
	SR	SH	LR	Poba2	*Populus*	*balsamifera*	balsam poplar
SM	SR	SH	LP	Potr5	*Populus*	*tremuloides*	quaking aspen
SM	SR	SH	LR	Psme	*Pseudotsuga*	*menziesii*	douglas fir
E				Saam2	*Salix*	*amygdaloides*	peachleaf willow
						SHRUBS	
SM	SR	SH	LP	Acgl	*Acer*	*glabrum*	Rocky Mountain maple
SM	SR	SH	LP	Alin2	*Alnus*	*incana*	mountain alder
SM	SR	SH	LP	Amal2	*Amelanchier*	*alnifolia*	saskatoon serviceberry
SM	SR			Amut	*Amelanchier*	*utahensis*	utah serviceberry
SM	SR	SH	LP	Aruv	*Arctostaphylos*	*uva-ursi*	kinnikinnik
SM	SR	SH		Arca13	*Artemisia*	*cana*	silver sagebrush
SM	SR			Arno4	*Artemisia*	*nova*	black sagebrush
SM	SR	SH	LP	Artr2	*Artemisia*	*tridentata*	big sagebrush
SM	SR	SH		Artr4	*Artemisia*	*tripartita*	threetip sagebrush
SM	SR	SH		Begl	*Betula*	*glandulosa*	bog birch
SM	SR	SH	LP	Beoc2	*Betula*	*occidentalis*	water birch
SM	SR	SH	LP	Cemo2	*Cercocarpus*	*montanus*	true mountain mahogany
			LP+	Cefe	*Ceanothus*	*fendleri*	Fendler's ceanothus
SM	SR	SH	LP	Ceve	*Ceanothus*	*velutinus*	snowbrush ceanothus
SM	SR			Chna2	*Chrysothamnus*	*nauseosus*	rubber rabbitbrush
SM	SR			Chpa13	*Chrysothamnus*	*parryi*	Parry rabbitbrush
SM	SR			Chvi8	*Chrysothamnus*	*viscidiflorus*	green rabbitbrush
			LP	Coca13	*Cornus*	*canadensis*	bunchberry dogwood
SM	SR	SH	LP	Cose16	*Cornus*	*sericea*	redosier dogwood
			LR	Crco6	*Crataegus*	*columbiana*	Columbian hawthorne
SM	SR			Crdo2	*Crataegus*	*douglasii*	black hawthorne
SM				Elco	*Elaeagnus*	*commutata*	silverberry
SM	SR			Gahu	*Gaultheria*	*humifusa*	alpine spicy wintergreen
	SR			Gusa2	*Gutierrezia*	*sarothrae*	broom snakeweed
			LP	Hodu	*Holodiscus*	*dumosus*	rock spirea
		SH+		Jaam	*Jamesia*	*americana*	cliff brush
SM	SR	SH	LP	Juco6	*Juniperus*	*communis*	common juniper
SM	SR	SH	LP	Jusc2	*Juniperus*	*scopulorum*	rocky mountain juniper

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Kami	*Kalmia*	*microphylla*	alpine laurel
SM	SR	SH		Loin5	*Lonicera*	*involucrata*	twinberry honeysuckle
	SR			Lota	*Lonicera*	*tatarica*	Tatarian honeysuckle
SM	SR	SH	LP	Mare11	*Mahonia*	*repens*	oregongrape
			LP	Pavi5	*Parthenocissus*	*vitacea*	wood bine
SM				Pamy	*Paxistima*	*myrsinites*	boxleaf myrtle
SM	SR	SH	LR	Pefl15	*Pentaphylloides*	*floribunda*	shrubby cinquefoil
			LP	Phma5	*Physocarpus*	*malvaceus*	mallow ninebark
			LP	Phmo4	*Physocarpus*	*monogynus*	mountain ninebark
SM	SR	SH	LP	Prvi	*Prunus*	*virginiana*	common chokecherry
SM	SR	SH	LP	Putr2	*Purshia*	*tridentata*	antelope bitterbrush
SM	SR	SH	LP	Pyas	*Pyrola*	*asarifolia*	liverleaf wintergreen
SM	SR		LP	Pych	*Pyrola*	*chlorantha*	greenflowered wintergreen
SM	SR		LR	Pymi	*Pyrola*	*minor*	snowline wintergreen
			LP	Pypi2	*Pyrola*	*picta*	whiteveined wintergreen
SM				Quga	*Quercus*	*gambelii*	Gambel oak
	SR		LR	Rhtr	*Rhus*	*trilobata*	skunkbush sumac
SM	SR			Riau	*Ribes*	*aureum*	golden currant
SM	SR	SH	LP	Rice	*Ribes*	*cereum*	wax currant
SM	SR	SH	LP	Riin2	*Ribes*	*inerme*	whitestem gooseberries
SM	SR		LR	Rila	*Ribes*	*lacustre*	prickly currant
SM	SR			Rimo2	*Ribes*	*montigenum*	gooseberry currant
SM				Rioxl	*Ribes*	*oxyacanthoides*	currant
	SR			Rioxs	*Ribes*	*setosum*	redshoot gooseberries
SM	SR	SH	LP	Roac	*Rosa*	*acicularis*	prickly rose
			LR	Roar3	*Rosa*	*arkansana*	prairie rose
SM	SR			Ronu	*Rosa*	*nutkana*	bristly Nootka rose
SM	SR		LP	Rowo	*Rosa*	*woodsii*	Wood's rose
SM	SR	SH	LP	Ruid	*Rubus*	*idaeus*	American red raspberry
SM	SR		LP	Rupa	*Rubus*	*parviflorus*	thimbleberry
	SR			Saar4	*Salix*	*arctica*	arctic willow
SM	SR	SH	LP	Sabe2	*Salix*	*bebbiana*	bebb willow
SM	SR	SH		Sabo2	*Salix*	*boothii*	Booth's willow
	SR	SH	LR	Sabr	*Salix*	*brachycarpa*	barrenground willow
	SR+	SH+		Saca4	*Salix*	*candida*	sageleaf willow
	SR			Saca6	*Salix*	*cascadensis*	cascade willow
			LP	Sadi	*Salix*	*discolor*	pussy willow
SM	SR		LR	Sadr	*Salix*	*drummondiana*	Drummond willow
SM	SR	SH	LP	Saex	*Salix*	*exigua*	sandbar willow
SM	SR	SH	LP	Sage2	*Salix*	*geyeriana*	Geyer's willow
	SR			Sagl	*Salix*	*glauca*	grayleaf willow
			LR+	Sair	*Salix*	*irrorata*	sandbar willow
SM	SR	SH	LP	Sala5	*Salix*	*lasiandra*	pacific willow
	SR		LP	Sali	*Salix*	*ligulifolia*	strapleaf willow
			LP	Salu2	*Salix*	*lutea*	yellow willow
SM	SR	SH	LR	Samo2	*Salix*	*monticola*	park willow
SM	SR	SH	LP	Sapl2	*Salix*	*planifolia*	diamondleaf willow
	SR			Sare2	*Salix*	*reticulata*	netleaf willow

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR		LP	Sasc	*Salix*	*scouleriana*	Scouler's willow
		SH*+		Sase2	*Salix*	*serissima*	autumn willow
SM	SR			Sawo	*Salix*	*wolfii*	Wolf's willow
SM	SR		LR	Sara2	*Sambucus*	*racemosa*	red elderberry
SM	SR	SH	LP	Shca	*Shepherdia*	*canadensis*	russet buffaloberry
SM	SR			Sosc2	*Sorbus*	*scopulina*	green mountain ash
	SR			Spbe2	*Spiraea*	*betulifolia*	white spirea
SM		SH	LP	Syal	*Symphoricarpos*	*albus*	common snowberry
SM	SR		LP	Syoc	*Symphoricarpos*	*occidentalis*	western snowberry
SM	SR			Syor2	*Symphirocarpos*	*oreophilus*	whortleleaf snowberry
			LP	Tory	*Toxicodendron*	*rydbergii*	Western poison ivy
SM	SR			Vace	*Vaccinium*	*cespitosum*	dwarf huckleberry
SM				Vamy2	*Vaccinium*	*myrtillus*	myrtle whortleberry
	SR			Vamyo	*Vaccinium*	*myrtillus* *var oreophilus*	dwarf bilberry
SM	SR		LR	Vasc	*Vaccinium*	*scoparium*	grouse whortleberry
	SR		LR	Vied	*Viburnum*	*edule*	mooseberry vibernum
			LR	Viri	*Vitis*	*riparia*	riverbank grape
	SR			Yugl	*Yucca*	*glauca*	small soapweed
					FORBS		
	SR			Abfr2	*Abronia*	*fragrans*	snowball sandverbena
SM	SR	SH	LP	Acmi2	*Achillea*	*millefolium*	common yarrow
SM	SR	SH	LP	Acco4	*Aconitum*	*columbianum*	Columbian monkshood
SM	SR	SH	LR	Acru2	*Actaea*	*rubra*	red baneberry
	SR			Admo	*Adoxa*	*moschatellina*	muskroot
SM				Agur	*Agastche*	*urticifolia*	nettleleaf giant hyssop
SM	SR		LR	Agau2	*Agoseris*	*aurantiaca*	orange agoseris
SM	SR	SH	LP	Aggl	*Agoseris*	*glauca*	pale agoseris
			LP	Agst	*Agrimonia*	*striata*	roadside agrimony
SM				Altr7	*Alisma*	*trivale*	northern water plantain
SM	SR			Alac4	*Allium*	*acuminatum*	tapertip onion
SM	SR		LP	Albr2	*Allium*	*brevistylum*	shortstyle onion
SM	SR	SH	LP	Alce2	*Allium*	*cernuum*	nodding onion
SM	SR	SH	LP	Alge	*Allium*	*geyeri*	Geyer's onion
	SR			Alsc	*Allium*	*schoenoprasum*	wild chive
SM	SR		LP	Alte	*Allium*	*textile*	textile onion
SM				Alal3	*Alyssum*	*alyssoides*	pale madwort
SM	SR			Alde	*Alyssum*	*desertorum*	desert madwort
	SR			Alpa7	*Alyssum*	*parviflorum*	European madwort
	SR			Amal	*Amaranthus*	*albus*	prostrate pigweed
	SR			Ambl	*Amaranthus*	*blitoides*	mat amaranth
	SR			Ampo2	*Amaranthus*	*powellii*	Powell's pigweed
	SR			Amre	*Amaranthus*	*retroflexus*	redroot pigweed
SM				Amme	*Amsinkia*	*menziesii*	Menzie's fiddleneck
SM	SR	SH	LP	Anma	*Anaphalis*	*margaritacea*	Western pearly everlasting
SM	SR	SH	LR	Anfi	*Androsace*	*filiformis*	filiform rock jasmine

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR	SH	LP	Anse4	*Androsace*	*septentrionalis*	pygmy flower rock jasmine
SM		SH		Anca8	*Anemone*	*canadensis*	Canadian anemone
SM			LP	Ancy	*Anemone*	*cylindrica*	candle anenome
SM	SR	SH		Anmu	*Anemone*	*multifida*	Pacific anemone
SM	SR		LP	Anpa	*Anemone*	*parviflora*	smallflowered anemone
SM	SR	SH		Anpa7	*Anemone*	*patens*	pasque flower
SM	SR	SH		Anum	*Angelica*	*ampla*	giant angelica
SM	SR			Angr3	*Angelica*	*grayi*	Gray's angelica
SM	SR			Anpi2	*Angelica*	*pinnata*	small-leaf Angelica
SM	SR			Anan2	*Antennaria*	*anaphaloides*	pearly pussytoes
	SR			Anar10	*Antennaria*	*aromatica*	scented pusseytoes
SM	SR			Anco	*Antennaria*	*corymbosa*	flattop pussytoes
SM				Andi2	*Antennaria*	*dimorpha*	low pusseytoes
SM				Anlu2	*Antennaria*	*luzuloides*	rush pusseytoes
SM	SR			Anme2	*Antennaria*	*media*	Rocky Mountain pussytoes
SM	SR		LP	Anmi3	*Antennaria*	*microphylla*	littleleaf pusseytoes
SM	SR	SH	LR	Anpa4	*Antennaria*	*parvifolia*	small-leaf pussytoes
SM		SH		Anro2	*Antennaria*	*rosea*	rosy pussytoes
SM	SR			Anum	*Antennaria*	*umbrinella*	umbder pussytoes
	SR			Anti	*Anthemis*	*tinctoria*	golden chamomile
SM	SR		LP	Apan2	*Apocynum*	*androsmaefolium*	spreading dogbane
		SH		Apfl	*Apocynum*	*xfloribundum*	intermediate dogbane
SM	SR		LP	Aqco	*Aquilegia*	*coerulea*	Colorado blue columbine
			LPC2*+	Aqla	*Aquilegia*	*laramiensis*	Laramie columbine
	SR			Arco24	*Arabis*	*confinis*	rockcress
SM	SR	SH	LP	Ardr	*Arabis*	*drummondii*	Drummond's rockcress
SM	SR		LP	Argl	*Arabis*	*glabra*	tower rockcress
	SR	SH	LP	Arhi	*Arabis*	*hirsuta*	hairy rockcress
SM	SR			Arho2	*Arabis*	*holboellii*	Hoboell's rockcress
SM				Arli	*Arabis*	*lignifera*	desert rockcress
SM				Arwi	*Arabis*	*williamsii*	Wind River rockcress
	SR			Aram	*Arceuthobium*	*americanum*	American dwarf mistletoe
	SR	SH		Arcy2	*Arceuthobium*	*cyanocarpum*	limber pine dwarf mistletoe
SM	SR			Arco5	*Arenaria*	*congesta*	ballhead sandwort
	SR	SH		Arfe3	*Arenaria*	*fendleri*	Fendler's sandwort
SM	SR		LP	Arho4	*Arenaria*	*hookeri*	Hooker's sandwort
SM	SR		LR	Arch3	*Arnica*	*chamissonis*	chamisso arnica
SM	SR	SH	LP	Arco9	*Arnica*	*cordifolia*	heartleaf arnica
SM	SR	SH	LR	Arfu3	*Arnica*	*fulgens*	foothill arnica
SM	SR			Argr14	*Arnica*	*gracilis*	smallhead arnica
SM	SR		LP	Arla8	*Arnica*	*latifolia*	broadleaf arnica
SM				Arlo6	*Arnica*	*longifolia*	longleaf arnica
SM	SR			Armo4	*Arnica*	*mollis*	hairy arnica
SM	SR			Arpa13	*Arnica*	*parryi*	Parry's arnica
SM	SR			Arry	*Arnica*	*rydbergii*	Rydberg's arnica
SM				Arab3	*Artemisia*	*absinthium*	absinth sagewort
SM	SR	SH		Arbi12	*Artemisia*	*biennis*	biennial wormwood
		SH		Arca12	*Artemisia*	*campestris*	field sagewort

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM		SH	LP	Ardr4	*Artemisia*	*dracunculus*	wormwood
SM	SR	SH		Arfr4	*Artemisia*	*frigida*	fringed sagewort
SM	SR	SH	LP	Arlu	*Artemisia*	*ludoviciana*	Louisianna sagewort
	SR+			Arpa18	*Artemisia*	*pattersonii*	Patterson sagewort
	SR			Arsc	*Artemisia*	*scopulorum*	alpine sagebrush
SM	SR		LP	Asas5	*Aster*	*ascendens*	Chile aster
		SH+		Asbo7	*Aster*	*borealis*	rush aster
E			LP	Asca6	*Aster*	*campestris*	field aster
			LP	Asci	*Aster*	*ciliolatus*	Lindley's aster
SM	SR			Asen2	*Aster*	*engelmannii*	Englemann's aster
			LR	Aser3	*Aster*	*ericoides*	heath aster
SM	SR		LR	Asfo	*Aster*	*foliaceus*	alpine leafybract aster
SM	SR		LP	Asgl3	*Aster*	*glaucodes*	gray aster
SM	SR			Ashe	*Aster*	*hesperius*	aster
SM				Asin3	*Aster*	*integrifolius*	thickstem aster
			LR	Asla5	*Aster*	*laevis*	smooth aster
SM	SR	SH	LP	Asoc	*Aster*	*occidentalis*	western aster
		SH+		Aspo5	*Aster*	*porteri*	Porter's aster
SM				Asab	*Astragalus*	*aboriginorum*	milkvetch
SM	SR			Asad3	*Astragalus*	*adsurgens*	standing milkvetch
SM	SR	SH		Asag2	*Astragalus*	*agrestis*	purple milkvetch
SM	SR	SH	LP	Asal7	*Astragalus*	*alpinus*	alpine milkvetch
SM	SR			Asbi2	*Astragalus*	*bisulcatus*	twogrooved milkvetch
	SR			Asbo	*Astragalus*	*bodinii*	Bodin's milkvetch
E			LP	Asca11	*Astragalus*	*canadensis*	Canada milkvetch
SM	SR			Ascr2	*Astragalus*	*crassicarpus*	groundplum milkvetch
E				Asdi5	*Astragalus*	*diversifolius*	meadow milkvetch
SM	SR			Asdr3	*Astragalus*	*drummondii*	Drummond's milkvetch
SM	SR		LR	Aseu2	*Astragalus*	*eucosmus*	elegant milkvetch
SM	SR			Asfl2	*Astragalus*	*flexuosus*	flexile milkvetch
SM				Asgr3	*Astragalus*	*gracilis*	slender milkvetch
SM				Aske	*Astragalus*	*kentrophyta*	spiny milkvetch
SM+				Asle9	*Astragalus*	*leptaleus*	meadow milkvetch
SM	SR			Asmi9	*Astragalus*	*miser*	weedy milkvetch
	SR	SH		Aspa13	*Astragalus*	*parryi*	Parry's milkvetch
SM				Aspe5	*Astragalus*	*pectinatus*	narrowleaf milkvetch
			LR	Aspl2	*Astragalus*	*plattensis*	Platte River milkvetch
SM				Aspu9	*Astragalus*	*purshii*	woollypod milkvetch
	SR	SH		Assh3	*Astragalus*	*shortianus*	Short's milkvetch
SM	SR	SH		Assp6	*Astragalus*	*spatulatus*	tufted milkvetch
E	SR			Aste5	*Astragalus*	*tenellus*	looseflower milkvetch
E		SH		Astr7	*Astragalus*	*tridactylis*	foothill milkvetch
SM+		SH+	LP+	Badi	*Bahia*	*dissecta*	bahia
SM	SR			Basa3	*Balsamorhiza*	*sagittata*	arrowleaf balsamroot
SM				Baor	*Barbarea*	*orthoceras*	American yellowrocket
SM	SR			Bavu	*Barbarea*	*vulgaris*	garden yellowrocket
SM				Bein2	*Berteroa*	*incana*	hoary false madwort
	SR+			Beal	*Besseya*	*alpina*	alpine besseya

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
	SR	SH		Bewy	*Besseya*	*wyomingensis*	Wyoming besseya
		SH		Bice	*Bidens*	*cernua*	nodding beggarticks
SM	SR	SH		Brgr	*Brickellia*	*grandiflora*	tasselflower brickellbush
E	SR			Cahe2	*Callitriche*	*hermaphroditica*	northern waterstarwort
SM	SR	SH		Capa52	*Callitriche*	*palustris*	waterstarwort
SM	SR	SH		Cagu	*Calochortus*	*gunnisonii*	Gunnison's mariposa lily
SM				Canu3	*Calochortus*	*nuttallii*	sego lily
SM	SR			Cale4	*Caltha*	*leptosepala*	white marshmarigold
SM	SR	SH		Cabu	*Calypso*	*bulbosa*	fairyslipper orchid
SM				Cami2	*Camelina*	*microcarpa*	littlepod falseflax
SM				Casu18	*Camissonia*	*subacaulis*	diffuse flower evening primrose
SM	SR	SH		Capa10	*Campanula*	*parryi*	Parry's bellflower
SM	SR	SH	LP	Caro2	*Campanula*	*rotundifolia*	bluebell bellflower
	SR+			Caun2	*Campanula*	*uniflora*	artic bellflower
SM	SR			Cabu2	*Capsella*	*bursa-pastoris*	shepherd's purse
SM	SR	SH		Cabr6	*Cardamine*	*breweri*	Brewer's bittercress
SM	SR			Caco6	*Cardamine*	*cordifolia*	heartleaf bittercress
SM			LP	Caol	*Cardamine*	*oligosperma*	Idaho bittercress
SM				Cape3	*Cardamine*	*pensylvanica*	Pensylvania bittercress
SM	SR			Canu4	*Carduus*	*nutans*	nodding plumeless thistle
SM	SR	SH		Caan7	*Castilleja*	*angustifolia*	northwestern Indian paintbrush
SM	SR	SH		Cafl7	*Castilleja*	*flava*	yellow Indian paintbrush
SM	SR	SH		Cali4	*Castilleja*	*linariifolia*	Wyoming Indian paintbrush
SM	SR			Cami12	*Castilleja*	*miniata*	scarlet Indian paintbrush
SM	SR			Carh4	*Castilleja*	*rhexifolia*	splitleaf Indian paintbush
SM		SH		Case4	*Castilleja*	*septentrionalis*	Indian paintbrush
SM	SR		LP	Casu12	*Castilleja*	*sulphurea*	sulfur paintbrush
SM	SR	SH	LP	Cear4	*Cerastium*	*arvense*	field chickweed
SM	SR			Cefo2	*Cerastium*	*fontanum*	chickweed
SM				Cenu2	*Cerastium*	*nutans*	nodding chickweed
SM				Cete5	*Ceratocephalus*	*testiculatus*	curveseed butterwort
SM	SR			Chdo	*Chaenactis*	*douglasii*	Douglas' dustymaiden
	SR	SH		Cher	*Chamaerhodos*	*erecta*	little rose
SM	SR			Chat	*Chenopodium*	*atrovirens*	Pinyon goosefoot
SM	SR	SH		Chbe4	*Chenopodium*	*berlanderi*	pitseed goosefoot
	SR+			Chca4	*Chenopodium*	*capitatum*	blite goosefoot
	SR			Chde	*Chenopodium*	*dessicatum*	aridland goosefoot
E	SR			Chfr3	*Chenopodium*	*fremontii*	Fremont's goosefoot
SM	SR			Chov	*Chenopodium*	*overi*	Over's goosefoot
	SR			Chpr5	*Chenopodium*	*pratericola*	desert goosefoot
SM				Chru	*Chenopodium*	*rubrum*	red goosefoot
SM	SR	SH	LP	Chum	*Chimaphila*	*umbellata*	pipsissewa
SM+	SR+			Chja	*Chionophila*	*jamesii*	Rocky Mountain snowlover
SM				Chte2	*Chorispora*	*tenella*	crossflower
SM	SR			Chle80	*Chrysanthemum*	*leucanthemum*	chyrsanthemum
			LP	Cima2	*Cicuta*	*maculata*	spotted water hemlock
SM	SR	SH	LP	Ciar4	*Cirsium*	*arvense*	Canadian thistle
SM	SR	SH		Cica11	*Cirsium*	*canescens*	prairie thistle

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Cice	*Cirsium*	*centaureae*	graygreen thistle
SM	SR	SH	LP	Cifl	*Cirsium*	*Flodmanii*	Flodman's thistle
SM	SR			Cipu3	*Cirsium*	*pulcherrimum*	Wyoming thistle
			LR	Cisc2	*Cirsium*	*scariosum*	meadow thistle
			LR	Cisc3	*Cirsium*	*scopulorum*	mountain thistle
SM	SR			Citic	*Cirsium*	*tioganum*	Colorado thistle
SM				Civu	*Cirsium*	*vulgare*	bull thistle
	SR			Ciro2	*Cistanthe*	*rosea*	rosy pussypaws
SM	SR	SH		Clla2	*Claytonia*	*lanceolata*	lanceleaf springbeauty
	SR			Clme	*Claytonia*	*megarrhiza*	alpine springbeauty
			LP	Clpe	*Claytonia*	*perfoliata*	miner's lettuce
SM	SR			Clhi	*Clematis*	*hirsutissima*	hairy clematis
SM	SR		LR	Clli2	*Clematis*	*ligusticifolia*	western white clematis
SM	SR		LP	Cloc2	*Clematis*	*occidentalis*	Western blue virgin's bower
SM	SR			Clse	*Cleome*	*serrulata*	rocky mountain beeplant
	SR			Covi6	*Coenoglossum*	*viride*	satyr bogorchid
SM	SR	SH		Copa3	*Collinsia*	*parviflora*	small flower blue-eyed Mary
SM	SR	SH	LR	Coli2	*Collomia*	*linearis*	narrowleaf mountain trumpet
SM	SR	SH		Coum	*Comandra*	*umbellata*	bastard toadflax
			LR	Coma2	*Conium*	*maculatum*	poison hemlock
SM	SR	SH	LP	Cosc2	*Conioselinum*	*scopulorum*	Rocky Mtn. hemlock parsley
SM	SR	SH	LP	Coma4	*Corallorhiza*	*maculata*	summer coralroot
E	SR			Cost	*Corallorhiza*	*striata*	hooded coralroot
SM	SR			Cotr3	*Corallorhiza*	*trifida*	yellow coralroot
SM	SR	SH	LP	Coau2	*Corydalis*	*aurea*	scrambled eggs
SM	SR			Cora5	*Cordylanthus*	*ramosus*	bushy birdbeak
SM	SR	SH	LR	Crac2	*Crepis*	*acuminata*	longleaf hawksbeard
	SR			Crat	*Crepis*	*atribarba*	slender hawksbeard
SM				Crin4	*Crepis*	*intermedia*	limestone hawksbeard
	SR	SH		Crmo4	*Crepis*	*modocensis*	Siskiyou hawksbeard
	SR			Croc	*Crepis*	*occidentalis*	largeflower hawksbeard
SM	SR	SH	LR	Crru3	*Crepis*	*runcinata*	fiddleleaf hawksbeard
			LP	Craf	*Cryptantha*	*affinis*	quill catseye
	SR			Cram3	*Cryptantha*	*ambigua*	basin catseye
SM	SR			Crce	*Cryptantha*	*celosoides*	roughseed catseye
SM				Crca7	*Cryptantha*	*caespitosa*	cryptantha
SM	SR			Crfe3	*Cryptantha*	*fendleri*	fendlers cryptantha
SM	SR			Crfl6	*Cryptantha*	*flavoculata*	cryptantha
	SR			Crke	*Cryptantha*	*kelseyana*	Kelsey's catseye
SM				Crse3	*Cryptantha*	*sericea*	silky catseye
SM				Crwa2	*Cryptantha*	*watsonii*	Watson's catseye
	SR			Crth	*Cryptantha*	*thyrsiflora*	Torrey's catseye
SM	SR	SH		Crvi4	*Cryptantha*	*virgata*	miner's candle
E				Cyac	*Cymopterus*	*acaulis*	plains springparsley
	SR+			Cyal9	*Cymopterus*	*alpinus*	alpine cymopterus
SM				Cyle6	*Cymopterus*	*lemmonii*	cymopterus
	SR			Cyof	*Cynoglossum*	*officinale*	gypsy flower
SMC2+	SRC2*+			Cyfa	*Cypripedium*	*fasciculatum*	clustered ladyslipper

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Deba2	*Delphinium*	*barbeyi*	tall larkspur
SM				Debi	*Delphinium*	*bicolor*	little larkspur
SM	SR			Dege2	*Delphinium*	*geyeri*	Geyer's larkspur
SM	SR	SH	LP	Denu2	*Delphinium*	*nuttallianum*	Nuttall's larkspur
SM	SR	SH	LP	Deoc	*Delphinium*	*occidentale*	duncecap larkspur
SM	SR	SH	LR	Dein5	*Descurania*	*incana*	mountain tansymustard
SM	SR			Depi	*Descurania*	*pinnata*	Western tansymustard
SM	SR			Deso2	*Descurania*	*sophia*	herb sophia
	SR			Dide	*Dianthus*	*deltoides*	maiden pink
SM				Ditr2	*Disporum*	*trachycarpum*	roughfruit fairybells
SM	SR	SH	LP	Dopu	*Dodecatheon*	*pulchellum*	dark throat shootingstar
SM	SR			Dral4	*Draba*	*albertina*	slender whitlowgrass
	SR			Drap	*Draba*	*apiculata*	draba
SM	SR			Drau	*Draba*	*aurea*	golden whitlowgrass
	SR			Drca4	*Draba*	*cana*	hoary whitlowgrass
SM	SR			Drcr2	*Draba*	*crassifolia*	thickleaf whitlowgrass
	SR			Drfl	*Draba*	*fladnizensis*	Austrian whitlowgrass
	E			Drgl6	*Draba*	*globosa*	beavertip whitlowgrass
SM				Drlo	*Draba*	*lonchocarpa*	lancepod whitlowgrass
SM		SH		Drne	*Draba*	*nemorosa*	woodland whitlowgrass
SM	SR			Drol	*Draba*	*oligosperma*	fewseed whitlowgrass
SM+				Drsp	*Draba*	*spectabilis*	showy whitlowgrass
	SR			Drst4	*Draba*	*streptocarpa*	pretty whitlowgrass
SM	SR		LP	Drpa2	*Dracocephalum*	*parviflorum*	American dragonhead
E				Elny	*Ellisia*	*nyctelea*	Aunt Lucy
SM	SR	SH		Elca7	*Elodea*	*canadensis*	Canadian waterweed
SM	SR			Epan4	*Epilobium*	*anagallidifolium*	alpine willowherb
SM	SR	SH	LP	Epan2	*Epilobium*	*angustifolium*	fireweed
SM	SR			Epbr3	*Epilobium*	*brachycarpum*	autumn willowweed
SM	SR	SH	LR	Epci	*Epilobium*	*ciliatum*	hairy willowherb
	SR			Epcl	*Epilobium*	*clavatum*	clubfoot willowherb
SM	SR		LR	Epha	*Epilobium*	*halleanum*	glandular willowherb
SM	SR			Epho	*Epilobium*	*hornemannii*	Hornemann's willowherb
SM				Epla3	*Epilobium*	*lactiflorum*	milkflower willowherb
	SR			Epla	*Epilobium*	*latifolium*	dwarf fireweed
	SR			Epor2	*Epilobium*	*oregoniense*	slimstem willowherb
		SH		Eppa	*Epilobium*	*palustre*	marsh willowherb
SM	SR			Epsa	*Epilobium*	*saximontanum*	Rocky Mountain willowherb
SM	SR		LP	Erac2	*Erigeron*	*acris*	bitter fleabane
SM	SR	SH		Erca2	*Erigeron*	*caespitosus*	tufted fleabane
SM	SR	SH	LP	Erco4	*Erigeron*	*compositus*	fernleaf fleabane
			LP	Erco5	*Erigeron*	*corymbosus*	large mountain fleabane
SM				Erdi4	*Erigeron*	*divergens*	spreading fleabane
SM	SR	SH		Erea	*Erigeron*	*eatonii*	Eaton's fleabane
SM+	SR+		LP+	Erel9	*Erigeron*	*elatior*	tall fleabane
		SH		Eren	*Erigeron*	*engelmanii*	Engelmann's fleabane
SM	SR		LP	Erex4	*Erigeron*	*eximius*	sprucefir fleabane
SM				Erfl	*Erigeron*	*flagellaris*	trailing fleabane

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR	SH	LP	Erfo3	*Erigeron*	*formosissimus*	beautiful fleabane
SM	SR	SH	LR	Ergl2	*Erigeron*	*glabellus*	streamside fleabane
SM				Erle6	*Erigeron*	*leiomerus*	rockslide yellow fleabane
SM	SR			Erlo	*Erigeron*	*lonchophyllus*	spearleaf fleabane
SM+	SR+			Erme2	*Erigeron*	*melanocephalus*	black-headed fleabane
SM	SR			Erne2	*Erigeron*	*nematophyllus*	needleleaf fleabane
SM	SR			Erpe3	*Erigeron*	*peregrinus*	subalpine fleabane
SM+	SR+			Erpi6	*Erigeron*	*pinnatisectus*	featherleaf fleabane
SM				Erpu2	*Erigeron*	*pumilus*	shaggy fleabane
	SR			Ersi3	*Erigeron*	*simplex*	one-stem fleabane
SM	SR	SH	LR	Ersp4	*Erigeron*	*speciosus*	aspen fleabane
SM	SR		LP	Ersu2	*Erigeron*	*subtrinervis*	three-nerve fleabane
E				Erui	*Erigeron*	*uintahensis*	Uinta fleabane
SM	SR	SH		Erur2	*Erigeron*	*ursinus*	Bear River fleabane
SM	SR			Erve2	*Erigeron*	*vetensis*	early blue top fleabane
E	SR			Eral4	*Eriogonum*	*alatum*	winged buckwheat
SM	SR			Erbr5	*Eriogonum*	*brevicaule*	shortstemmed buckwheat
	SR			Erce2	*Eriogonum*	*cernuum*	nodding eriogonum
SM+	SR+			Erex2	*Eriogonum*	*exilifolium*	dropleaf buckwheat
	SR			Erfl4	*Eriogonum*	*flavum*	yellow eriogonum
	SR			Erjaf	*Eriogonum*	*jamesii*	james wildbuckwheat
	SR			ermi4	*Eriogonum*	*microthecum*	slender buckwheat
SM	SR			Erov	*Eriogonum*	*ovalifolium*	ovalleaf eriogonum
SM				Erpa9	*Eriogonum*	*pauciflorum*	fewflower buckwheat
SM	SR	SH	LP	Erum	*Eriogonum*	*umbellatum*	sulphur wild buckwheat
	SR			Erna	*Eritrichium*	*nanum*	artic alpine forget-me-not
SM				Erci6	*Erodium*	*cicutarium*	redstem storksbill
SM	SR	SH		Erca14	*Erysimum*	*capitatum*	sanddune wallflower
SM	SR			Erch9	*Erysimim*	*cheiranathoides*	wormseed wallflower
SM				Erin7	*Erysimum*	*inconspicuum*	shy wallflower
SM	SR			Ergr9	*Erythronium*	*grandiflorum*	dogtooth lily
	SR			Eues	*Euphorbia*	*esula*	wolf's milk
SM	SR			Euro5	*Euphorbia*	*robusta*	robust spurge
			LR	Eugr5	*Euthanmia*	*graminifolia*	flattop goldentop
SM	SR			Flpr	*Floerkea*	*proserpinacoides*	falsemermaidweed
SM				Frve	*Frageria*	*vesca*	woodland strawberry
SM	SR	SH	LP	Frvi	*Fragaria*	*virginiana*	Virginia strawberry
SM	SR	SH	LP	Frsp	*Frasera*	*speciosa*	showy frasera
	SR			Frat	*Fritillaria*	*atropurpurea*	spotted mission bells
SM				Frpu2	*Fritillaria*	*pudica*	yellow mission bells
SM				Gaap2	*Galium*	*aparine*	stickywilly
SM	SR			Gabi	*Galium*	*bifolium*	twinleaf bedstraw
SM	SR	SH	LP	Gabo2	*Galium*	*boreale*	northern bedstraw
SM	SR	SH	LR	Gatr2	*Galium*	*trifidum*	threepedal bedstraw
SM	SR		LP	Gatr3	*Galium*	*triflorum*	fragrant bedstraw
SM	SR	SH	LR	Gaar	*Gaillardia*	*aristata*	common gaillardia
	SR			Gaco5	*Gaura*	*coccinea*	scarlet beeblossom
	SR			Gade2	*Gayophytum*	*decipiens*	deceptive groundsmoke

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR	SH		Gadi2	*Gayophytum*	*diffusum*	spreading groundsmoke
SM	SR			Gara	*Gayophytum*	*racemosum*	blackfoot groundsmoke
E				Gara2	*Gayophytum*	*ramossissimum*	pleated gentian
SM+	SR+			Geaf	*Gentiana*	*affinis*	pleated gentian
	SR			Geal2	*Gentiana*	*algida*	whitish gentian
SM	SR	SH		Gefr	*Gentiana*	*fremontii*	moss gentian
SM	SR			Gepa	*Gentiana*	*parryi*	Parry's gentian
SM	SR		LR	Geam3	*Gentianella*	*amarella*	autumn dwarf gentian
	SR+			Gete4	*Gentianella*	*tenella*	Dane's dwarf gentian
	SR			Geba2	*Gentianopsis*	*barbellata*	perennial fringed gentian
SM	SR			Gede4	*Gentianopsis*	*detonsa*	windmill fringed gentian
		SH		Geat2	*Geranium*	*atropurpureum*	western purple cranesbill
			LP	Gebi2	*Geranium*	*bicknellii*	Bicknell's cranesbill
SM	SR	SH	LR	Geca3	*Geranium*	*caespitosum*	pineywoods geranium
SM	SR	SH	LP	Geri	*Geranium*	*richardsonii*	Richardson's geranium
SM	SR			Gevi2	*Geranium*	*viscosissimum*	sticky geranium
SM	SR		LP	Geal3	*Geum*	*aleppicum*	yellow avens
SM	SR	SH	LP	Gema4	*Geum*	*macrophyllum*	largeleaf avens
SM	SR		LP	Geri2	*Geum*	*rivale*	purple avens
	SR			Gero2	*Geum*	*rossii*	Ross avens
SM	SR	SH	LR	Getr	*Geum*	*triflorum*	prairiesmoke
E				Gile3	*Gilia*	*leptomeria*	sand gilia
SM	SR			Gipi	*Gilia*	*pinnatifida*	sticky gilia
E				Gitw	*Gilia*	*tweedyi*	Tweedy's gilia
	SR			Glma	*Glaux*	*maritima*	seamilkwort
	SR		LP	Glle3	*Glycyrrhiza*	*lepidota*	American licorice
	SR	SH		Gnpa	*Gnaphalium*	*palustre*	western marsh cudweed
	SR		LR	Gnul	*Gnaphalium*	*uliginosum*	marsh cudweed
	SR			Gnvi	*Gnaphalium*	*viscosum*	winged cudweed
SM	SR			Goob2	*Goodyera*	*oblongifolia*	rattlesnakeplantain
SM	SR	SH		Grsq	*Grindelia*	*squarrosa*	curlycup gumweed
	SR	SH		Grsu	*Grindelia*	*subalpina*	subalpine gumweed
SM				Gypa2	*Gymnosteris*	*parvula*	smallflower gymnosteris
SM	SR	SH	LP	Hafl2	*Hackelia*	*floribunda*	manyflowered stickseed
	SR			Havi3	*Halimolobos*	*virgata*	rod halimolobos
SM				Hapa	*Hackelia*	*patens*	common stickseed
SM	SR			Haac	*Haplopappus*	*acaulis*	stemless goldenweed
	SR			Haar2	*Haplopappus*	*armenoides*	goldenweed
SM	SR			Hanu2	*Haplopappus*	*nuttallii*	Nuttall's goldenweed
	SR+			Hapy	*Haplopappus*	*pygmaeus*	pygmy goldenweed
	SR	SH		Hatr	*Harbouria*	*trachypleura*	whiskbroom parsley
		SH	LR	Heal	*Hedysarum*	*alpinum*	alpine sweetvetch
SM	SR		LP	Hequ2	*Helianthella*	*quinquinervis*	fivenerve helianthella
SM	SR	SH		Heun	*Helianthella*	*uniflora*	oneflower helianthella
	SR			Hean3	*Helianthus*	*annuus*	common sunflower
SM		SH	LR	Henu	*Helianthus*	*nuttallii*	Nuttall's sunflower
E	SR	SH	LP	Hepu3	*Helianthus*	*pumilus*	little sunflower
SM	SR	SH	LP	Hesp6	*Heracleum*	*sphondylium*	eltrot

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Hema3	*Hesperis*	*matronalis*	dames rocket
SM	SR			Hefu3	*Heterotheca*	*fulcrata*	rockyscree false goldenaster
SM	SR			Heho3	*Heterotheca*	*horrida*	goldaster
SM	SR	SH	LP	Hevi4	*Heterotheca*	*villosa*	hairy goldaster
		SH		Hebr2	*Heuchera*	*bracteata*	bracted alumroot
SM	SR	SH	LP	Hepa11	*Heuchera*	*parvifolia*	littleleaf alumroot
SM	SR		LP	Hial2	*Hieracium*	*albiflorum*	white hawkweed
SM	SR			Higr	*Hieracium*	*gracile*	slender hawkweed
			LR	Hium	*Hieracium*	*umbellatum*	narrowleaf hawkweed
E	SR			Hivu2	*Hippuris*	*vulgaris*	common marestail
E	SR			Hulu	*Humulus*	*lupulus*	common hop
SM	SR			Hyca4	*Hydrophyllum*	*capitatum*	ballhead waterleaf
		SH		Hyfe	*Hydrophyllum*	*fendleri*	Fendler's waterleaf
E			LP	Hyfi	*Hymenopappus*	*filifolius*	fineleaf hymenopappus
SM	SR	SH	LP	Hyac4	*Hymenoxys*	*acaulis*	actinea
	SR			Hygr5	*Hymenoxys*	*grandiflora*	rydbergia
SM		SH		Hyto2	*Hymenoxys*	*torreyana*	hymenoxys
SM		SH		Hyni	*Hyoscyamus*	*niger*	black henbane
SM	SR	SH		Hyfos	*Hypericum*	*formosum*	southwestern St. Johnswort
SM	SR			Hymo3	*Hypopitys*	*monotropa*	pinesap
SM	SR			Ilri	*Iliamna*	*rivularis*	streambank globemallow
SM	SR	SH	LP	Ipag	*Ipomopsis*	*aggregata*	skyrocket gilia
SMC2*				Ipagw	*I. aggregata*	*ssp. weberi*	Weber's ipomopsis
SM				Ipco5	*Ipomopsis*	*congesta*	ballhead gilia
SM	SR	SH		Ipsp	*Ipomopsis*	*spicata*	spiked gilia
	SR+		LM+	Ipte4	*Ipomopsis*	*tenuituba*	slendertube skyrocket
SM	SR	SH	LP	Irmi	*Iris*	*missouriensis*	Rocky Mountain iris
	SR			Ivxa	*Iva*	*xanthifolia*	giant sumpweed
			LP	Lalu	*Lactuca*	*ludoviciana*	biannual lettuce
SM				Latap	*Lactuca*	*tatarica*	blue lettuce
SM	SR	SH		Lare	*Lappula*	*redowskii*	western stickseed
SM	SR			Lala3	*Lathyrus*	*lanszwertii*	thickleaf peavine
E	SR			Letr	*Lemna*	*trisulca*	star duckweed
SM	SR			Lede	*Lepidium*	*densiflorum*	common pepperweed
SM				Lepe2	*Lepidium*	*perfoliatum*	clasping pepperweed
SM	SR			Lera2	*Lepidium*	*ramossissimum*	many-branched pepperweed
SM	SR			Lepu	*Leptodactylon*	*pungens*	granite gilia
SM+				Leal	*Lesquerella*	*alpina*	alpine bladderpod
SM	SR			Lelu	*Lesquerella*	*ludoviciana*	foothill bladderpod
SM	SR	SH		Lemo3	*Lesquerella*	*montana*	mountain bladderpod
E				Lepa7	*Lesquerella*	*parvula*	pygmy bladderpod
SM	SR			Lepy2	*Lewisia*	*pygmaea*	pigmy bitterroot
SM	SR			Lere7	*Lewisia*	*rediviva*	Oregon bitterroot
SM				Letr2	*Lewisia*	*triphylla*	three-leaf lewisia
	SR			Lemo4	*Leucocrinum*	*montanum*	common starlily
			LP	Lili	*Liatris*	*ligulistylis*	Rocky mountain gayfeather
	SR		LP	Lipu	*Liatris*	*punctata*	dotted gayfeather
SM			LR	Lifi	*Ligusticum*	*filicinum*	fernleaf licoriceroot

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR		LP	Lipo	*Ligusticum*	*porteri*	Porter's licoriceroot
SM				Lite2	*Ligusticum*	*tenuifolium*	Idaho licoriceroot
	SR	SH	LP	Liph	*Lilium*	*philadelphicum*	wood lily
E	SR	SH		Liaq	*Limosella*	*aquatica*	water mudwort
SM	SR			Lise	*Linanthus*	*septentrionalis*	northern linanthus
	SR	SH		Lida	*Linaria*	*dalmatica*	dalmatian toadflax
SM	SR			Livu2	*Linaria*	*vulgaris*	butter and eggs
SM	SR	SH	LP	Libo3	*Linnaea*	*borealis*	twinflower
	SR			Liki2	*Linum*	*kingii*	King's flax
SM	SR			Lile3	*Linum*	*lewisii*	prairie flax
	SR		LP	Lico5	*Listera*	*convallarioides*	broadlipped twayblade
SM	SR			Lico6	*Listera*	*cordata*	heartleaf twayblade
SM	SR			Ligl2	*Lithophragma*	*glabrum*	smooth woodlandstar
SM				Lipa5	*Lithophragma*	*parviflorum*	smallflower woodlandstar
SM	SR			Liin2	*Lithospermum*	*incisum*	narrowleaf gromwell
SM	SR			Liru4	*Lithospermum*	*ruderale*	western gromwell
SM+				Lobi	*Lomatium*	*bicolor*	Wasatch desert parsley
SM	SR			Lodi	*Lomatium*	*dissectum*	fernleaf biscuitroot
E				Lofo	*Lomatium*	*foeniculatum*	desert biscuitroot
SM				Loor	*Lomatium*	*orientale*	northern Idaho biscuitroot
SM				Losa3	*Lomatium*	*sandbergii*	Sandberg biscuitroot
SM	SR			Lotr2	*Lomatium*	*triternatum*	nineleaf biscuitroot
	SR+	SH+		Loro	*Lomatogonium*	*rotatum*	marsh felwort
SM	SR	SH	LP	Luar3	*Lupinus*	*argenteus*	silvery lupine
SM				Luca	*Lupinus*	*caudatus*	Kellogg's spurred lupine
SM	SR			Lucac2	*Lupinus*	*lepidus*	Pacific lupine
SM				Lupa8	*Lupinus*	*parviflorus*	littleflower lupine
SM				Lupo2	*Lupinus*	*polyphyllus*	bigleaf lupine
SM				Lipu	*Lupinus*	*pusilllus*	rusty lupine
SM				Luse4	*Lupinus*	*sericeus*	silky lupine
			LR	Lyam	*Lycopus*	*americanus*	American water horehound
	SR			Lyju	*Lygodesmia*	*juncea*	rush skeletonplant
			LP	Lyci	*Lysimachia*	*ciliata*	fringed loosestrife
		SH+		Mabi	*Machaeranthera*	*bigelovii*	Bigalow's tansyaster
SM	SR		LP	Maca2	*Machaeranthera*	*canescens*	hoary aster
E	SR*+			Macoc	*Machaeranthera*	*coloradoensis*	Colorado tansy-aster
SM	SR		LP	Magl2	*Madia*	*glomerata*	mountain tarweed
SM			LP	Mara7	*Maianthemum*	*racemosum*	feathery false solomon's seal
SM	SR	SH	LP	Mast4	*Maianthemum*	*stellatum*	starry false solomon's seal
SM				Mane	*Malva*	*neglecta*	cheeseweed mallow
			LP	Mavu	*Marrubium*	*vulgare*	common horehound
SM				Mama10	*Matricaria*	*maritima*	false mayweed
	SR	SH		Mama11	*Matricaria*	*matricarioides*	pineappleweed
SM	SR	SH		Melu	*Medicago*	*lupulina*	black medic
	SR			Mesa	*Medicago*	*sativa*	alfalfa
	SR			Meal2	*Melilotus*	*albus*	white sweetclover
	SR			Meof	*Melilotus*	*officinalis*	yellow sweetclover
SM	SR	SH	LP	Mear4	*Mentha*	*arvensis*	wild mint

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM				Meal6	*Mentzelia*	*albicaulis*	whitestem blazingstar
	SR			Mede2	*Mentzelia*	*decapetala*	tenpetal blazingstar
SM	SR			Medi	*Mentzelia*	*dispersa*	bushy blazingstar
	SR			Memo4	*Mentzelia*	*montana*	varigated bract blazingstar
	SR			Memu3	*Mentzelia*	*multiflora*	manyflowered mentzelia
	SR			Meru	*Mentzelia*	*rusbyi*	Rusby's blazingstar
	SR			Mesi	*Mentzelia*	*sinuata*	leechleaf blazingstar
SM	SR			Metr3	*Menyanthes*	*trifoliata*	common buckbean
SM				Meal7	*Mertensia*	*alpina*	alpine bluebells
SM+				Mebr	*Mertensia*	*brevistyla*	shortstyle bluebells
SM	SR	SH	LR	Meci3	*Mertensia*	*ciliata*	mountain bluebells
SM	SR	SH		Mehu2	*Mertensia*	*humilis*	Rocky Mountain bluebells
SM	SR		LP	Mela3	*Mertensia*	*lanceolata*	lanceleaf bluebells
SM	SR			Mevi4	*Mertensia*	*viridis*	bluebells
SM	SR		LP	Minu	*Microseris*	*nutans*	nodding microseris
SM	SR	SH		Migr	*Microsteris*	*gracilis*	microsteris
SM	SR		LP	Mili3	*Mirabilis*	*linearis*	narrowleaved four-o'clock
			LR	Miny	*Mirabilis*	*nyctaginea*	heartleaf four-o'clock
			LR+	Mibr5	*Mimulus*	*breweri*	Brewer's monkeyflower
SM	SR			Mifl2	*Mimulus*	*floribundus*	manyflowered monkeyflower
SM	SR		LR	Migu	*Mimulus*	*guttatus*	seep monkeyflower
SM	SR			Mile2	*Mimulus*	*lewsii*	purple monkeyflower
SM				Mimo3	*Mimulus*	*moschatus*	musk monkeyflower
	SR			Misu2	*Mimulus*	*suksdorfii*	Suksdorf's monkeyflower
SM	SR			Miti	*Mimulus*	*tilingii*	Tilina's monkeyflower
	SR			Minu4	*Minuartia*	*nuttallii*	Nuttall's sandwort
SM	SR			Miob2	*Minuartia*	*obtusiloba*	twinflower sandwort
E	SR			Miru3	*Minuartia*	*rubella*	beautiful sandwort
SM				Mili3	*Mirablils*	*linearis*	narrowleaf four o'clock
SM	SR		LP	Mipe	*Mitella*	*pentandra*	fivestamen miterwort
SM				Mist3	*Mitella*	*stauropetala*	smallfower miterwort
SM	SR			Mola6	*Moehringia*	*lateriflora*	bluntleaf sandwort
SM			LP	Mofi	*Monarda*	*fistulosa*	wildbergamot beebalm
SM	SR			Moun2	*Moneses*	*uniflora*	single delight
SM	SR	SH		Monu	*Monolepis*	*nuttalliana*	Nuttall's povertyweed
SM	SR	SH		Moch	*Montia*	*chamissoi*	water miner's lettuce
	SR	SH		Mysi	*Myriophyllum*	*sibericum*	short-spike water milfoil
SM				Myas2	*Myosotis*	*asiatica*	Asiatic forget-me-not
E	SR			Nebr	*Nemophila*	*breviflora*	basin nemophila
SM				Niat	*Nicotiana*	*attenuata*	coyote tobacco
SM	SR			nepo2	*Nuphar*	*polysepala*	Rocky Mountain cowlily
SM	SR	SH		Oece2	*Oenothera*	*cespitosa*	tufted eveningprimrose
SM	SR	SH		Oeco2	*Oenothera*	*coronopifolia*	crownleaf eveningprimrose
SM				Oefl	*Oenothera*	*flava*	yellow eveningprimrose
SM	SR			Oenu	*Oenothera*	*nuttallii*	Nuttall's eveningprimrose
SM	SR	SH	LP	Oevi	*Oenothera*	*villosa*	hairy eveningprimrose
SM	SR		LP	Oppo	*Opuntia*	*polyacantha*	plains pricklypear
SM	SR			Orfa	*Orobanche*	*fasciculata*	clustered broomrape

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Orli	*Orogenia*	*linearifolia*	indianpotato
SM	SR	SH	LP	Orse	*Orthilia*	*secunda*	sidebells wintergreen
SM	SR	SH	LP	Orlu2	*Orthocarpus*	*luteus*	yellow owlclover
SM	SR			Osch	*Osmorhiza*	*chilensis*	sweet cicely
SM	SR		LP	Osde	*Osmorhiza*	*depauperata*	bluntseed sweetroot
SM				Osoc	*Osmorhiza*	*occidentalis*	western sweetroot
SM	SR			Oxfe	*Oxypolis*	*fendleri*	Fendler's cowbane
SM	SR		LP	Oxdi3	*Oxyria*	*digyna*	alpine mountain sorrel
	SR	SH	LP	Oxca4	*Oxytropis*	*campestris*	cold mountain crazyweed
	SR			Oxde2	*Oxytropis*	*deflexa*	hangpod crazyweed
SM	SR			Oxla2	*Oxytropis*	*lagopus*	haresfoot pointloco
SM	SR	SH	LR	Oxla3	*Oxytropis*	*lambertii*	Lambert's locoweed
SM	SR			Oxmu	*Oxytropis*	*multiceps*	southwestern locoweed
SM	SR	SH		Oxse	*Oxytropis*	*sericea*	silvery oxytrope
SM		SH		Oxsp	*Oxytropis*	*splendens*	showy pointvetch
			LP	Oxvi2	*Oxytropis*	*viscida*	sticky crazyweed
SM	SR			Pafi3	*Parnassia*	*fimbriata*	Rocky Mountain parnassia
	SR	SH		Papa8	*Parnassia*	*palustris*	northern grass of Parnassus
			LP	Pade4	*Paronychia*	*depressa*	spreading nailwort
	SR+			Papu2	*Paronychia*	*pulvinata*	Rocky Mountain nailwort
SM	SR		LP	Pase	*Paronychia*	*sessiliflora*	creeping nailwort
SM	SR		LR	Pebr	*Pedicularis*	*bracteosa*	bracted towering lousewort
E		SH		Pecr	*Pedicularis*	*crenulata*	meadow lousewort
SM	SR	SH	LR	Pegr2	*Pedicularis*	*groenlandica*	elephanthead lousewort
	SR		LR	Pepa3	*Pedicularis*	*parryi*	Parry's lousewort
	SR	SH	LP	Pepr7	*Pedicularis*	*procera*	giant lousewort
SM	SR			Pera	*Pedicularis*	*racemosa*	sickletop lousewort
SM	SR	SH		Pesi	*Pediocactus*	*simpsonii*	Simpson's hedgehog cactus
	SR			Pean4	*Penstemon*	*angustifolius*	broadbeard beardtongue
SM				Peca4	*Penstemon*	*caespitosus*	mat penstemon
SM	SR			Pecy6	*Penstemon*	*cyathophorus*	sagebrush beardtongue
E				Pefr	*Penstemon*	*fremontii*	Fremont's penstemon
SM	SR			Pegl3	*Penstemon*	*glaber*	sawsepal penstemon
SM				Pehu	*Penstemon*	*humilis*	low penstemon
	SR	SH	LP	Pela9	*Penstemon*	*laricifolius*	larchleaf beardtongue
SM	SR			Pepr2	*Penstemon*	*procerus*	littleflower penstemon
SM	SR			Pera2	*Penstemon*	*radicosus*	matroot penstemon
SM	SR	SH		Pery	*Penstemon*	*rydbergii*	Rydberg's penstemon
SM	SR			Pesa2	*Penstemon*	*saxosorum*	upland beardtongue
	SR	SH		Pese11	*Penstemon*	*secundiflorus*	sidebells penstemon
SM	SR	SH	LP	Pest2	*Penstemon*	*strictus*	Rocky Mountain penstemon
SM	SR	SH	LP	Pevi3	*Penstemon*	*virens*	Front Range beardtongue
SM	SR		LP	Pewh	*Penstemon*	*whippleanus*	Whipple's penstemon
SM	SR		LR	Pemo7	*Perideridia*	*montana*	yampa
	SR+	SH+	LP+	Pesa5	*Petasites*	*sagittatus*	arrowleaf sweet coltsfoot
	SR+		LP+	Phde2	*Phacelia*	*denticulata*	Rocky Mountain scorpionweed
SM	SR		LR	Phha	*Phacelia*	*hastata*	silverleaf phacelia
SM				Phhe2	*Phacelia*	*heterophylla*	varileaf phacelia

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
	SR			Phne3	*Phacelia*	*neomexicana*	New Mexico scorpionweed
SM	SR	SH		Phse	*Phacelia*	*sericea*	silky phacelia
SM	SR		LP	Phho	*Phlox*	*hoodii*	spiny phlox
SM				Phlo2	*Phlox*	*longifolia*	longleaf phlox
SM	SR			Phmu3	*Phlox*	*multiflora*	flowery phlox
	SR			Phpu5	*Phlox*	*pulvinata*	cushion phlox
SM				Phac4	*Physaria*	*acutifolia*	sharpleaf twinpod
SM+				Phvi7	*Physaria*	*vitulifera*	roundtip twinpod
SM			LR	Piun3	*Piperia*	*unalascensis*	Alaskan rainorchid
SM				Plma2	*Plantago*	*major*	common plantain
SM	SR		LP	Pltw	*Plantago*	*tweedyi*	Tweedy's plantain
E	SR			Plsc2	*Plagiobothrys*	*scouleri*	Scouler's popcorn flower
SM	SR		LP	Pldi3	*Platanthera*	*dilatata*	boreal bog orchid
SM	SR		LP	Plhy2	*Platanthera*	*hyperborea*	northern green orchid
	SR			Plob	*Platanthera*	*obtusata*	blunt bog orchid
	SR			Plst4	*Platanthera*	*stricta*	Modoc bog orchid
		SH+	LR+	Pobr8	*Polemonium*	*brandegei*	Brandegee's Jacob's ladder
SM	SR			Pooc2	*Polemonium*	*occidentale*	western polemonium
SM				Popu3	*Polemonium*	*pulcherrimum*	skunkleaf polemonium
	SR			Povi	*Polemonium*	*viscosum*	sticky polemonium
	SR			Poac3	*Polygonum*	*achoreum*	leathery knotweed
	SR	SH	LR	Poam8	*Polygonum*	*amphibium*	water knotweed
SM	SR	SH		Poav	*Polygonum*	*aviculare*	prostrate knotweed
SM	SR	SH	LR	Pobi6	*Polygonum*	*bistortoides*	American bistort
SM	SR	SH	LP	Podo4	*Polygonum*	*douglasii*	Douglas' knotweed
SM	SR			poke2	*Polygonum*	*kelloggii*	Kellogg's knotweed
	SR			Pora3	*Polygonum*	*ramosissimum*	bushy knotweed
SM	SR			Podoj2	*Polygonum*	*sawatchense*	knotweed
SM	SR			Povi3	*Polygonum*	*viviparum*	alpine bistort
	SR			Pwpoc	*Polygonum*	*watsonii*	Watson knotweed
E	SR	SH		Poal8	*Potamogeton*	*alpinus*	alpine pondweed
E				Poam5	*Potamogeton*	*amplifolius*	largeleaf pondweed
	SR			Poep2	*Potamogeton*	*epihydrus*	ribbonleaf pondweed
E	SR			Pofi2	*Potamogeton*	*filiformis*	fineleaf pondweed
		SH		Pofo3	*Potamogeton*	*foliosus*	leafy pondweed
	SR			Pofr3	*Potamogeton*	*friesii*	Frie's pondweed
SM	SR			Pogr8	*Potamogeton*	*gramineus*	variableleaf pondweed
E	SR			Pona4	*Potamogeton*	*natans*	floatingleaf pondweed
SM				Pope6	*Potamogeton*	*pectinatus*	sago pondweed
	SR			Popr5	*Potamogeton*	*praelongus*	whitestem pondweed
	SR			Popu7	*Potamogeton*	*pusillus*	small pondweed
	SR			Pori2	*Potamogeton*	*richardsonii*	Richardson's pondweed
	SR			Poro2	*Potamogeton*	*robbinsii*	Robbin's pondweed
SM				Poan5	*Potentilla*	*anserina*	silverweed cinquefoil
E	SR		LP	Poar7	*Potentilla*	*arguta*	tall cinquefoil
SM	SR			Pobi7	*Potentilla*	*biennis*	biennial cinquefoil
	SR			Pobi10	*Potentilla*	*bipinnatifida*	tansy cinquefoil
SM	SR			Poco13	*Potentilla*	*concinna*	elegant cinquefoil

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Podi2	*Potentilla*	*diversifolia*	varileaf cinquefoil
SM				Poef	*Potentilla*	*effusa*	branched cinquefoil
SM	SR	SH	LP	Pofi3	*Potentilla*	*fissa*	bigflower cinquefoil
E	SR			Pogl9	*Potentilla*	*glandulosa*	gland cinquefoil
SM	SR		LR	Pogr9	*Potentilla*	*gracilis*	northwest cinquefoil
SM	SR	SH		Pohi6	*Potentilla*	*hippiana*	wooly cinquefoil
SM				Poho2	*Potentilla*	*hookeriana*	Hooker's cinquefoil
	SR			Pogla	*Potentilla*	*glandulosa*	gland cinquefoil
SM	SR			Poni2	*Potentilla*	*nivea*	snowy cinquefoil
	SR	SH	LR	Pono3	*Potentilla*	*norvegica*	Norweigian cinquefoil
SM	SR			Poov2	*Potentilla*	*ovina*	sheep cinquefoil
	SR			Popa14	*Potentilla*	*palustris*	cinquefoil
SM		SH		Pope8	*Potentilla*	*pensylvanica*	Pennsylvania cinquefoil
SM	SR	SH	LR	Popl	*Potentilla*	*plattensis*	Platte River cinquefoil
SM	SR	SH		Popu9	*Potentilla*	*pulcherrima*	beauty cinquefoil
SM	SR			Poru3	*Potentilla*	*rubricaulis*	Rocky Mountain cinquefoil
E				Posu5	*Potentilla*	*subjuga*	Colorado cinquefoil
			LR	Prra	*Prenanthes*	*racemosa*	purple rattlesnakeroot
			E	Prram	*Prenanthes*	*racemosa*	
						ssp multiflora	many-flowered rattlesnakeroot
	SR			Prin	*Primula*	*incana*	silvery primrose
E	SR		LR	Prpa	*Primula*	*parryi*	Parry's primrose
SM	SR			Prvu	*Prunella*	*vulgaris*	common selfheal
SM	SR			Psja2	*Pseudostellaria*	*jamesiana*	tuber starwort
SM	SR	SH	LP	Ptan2	*Pterospora*	*andromeda*	woodland pinedrops
	SR+			Pycr2	*Pyrrocoma*	*crocea*	curlyhead goldenweed
	SR			Pyla	*Pyrrocoma*	*lanceolata*	lanceleaf goldenweed
SM				Pyun2	*Pyrrocoma*	*uniflora*	plantain goldenweed
E	SR			Raab	*Ranunculus*	*abortivus*	littleleaf buttercup
SM	SR		LP	Raac2	*Ranunculus*	*acriformis*	sharpleaf buttercup
SM				Raad	*Ranunculus*	*adoneus*	alpine buttercup
SM	SR			Raal	*Ranunculus*	*alismifolius*	plantainleaf buttercup
SM	SR	SH	LR	Raaq	*Ranunculus*	*aquatilis*	whitewater crowfoot
SM	SR	SH		Raca4	*Ranunculus*	*cardiophyllus*	heartleaf buttercup
SM	SR	SH		Racy	*Ranumculus*	*cymbalaria*	alkali buttercup
SM	SR			Raes	*Ranunculus*	*eschscholtzii*	Eschscholtz's buttercup
SM	SR			Rafl2	*Ranunculus*	*flammula*	spearwort buttercup
SM	SR			Ragl	*Ranunculus*	*glaberrimus*	sagebrush buttercup
	SR	SH		Ragm	*Ranunculus*	*gmelinii*	Gmelin's buttercup
SM	SR			Rain	*Ranunculus*	*inamoenus*	graceful buttercup
E				Rajo	*Ranunculus*	*jovis*	Utah buttercup
SM		SH	LR	Rama2	*Ranunculus*	*macounii*	Macoun's buttercup
SM	SR			Rape	*Ranunculus*	*pedatifidus*	surefoot buttercup
	SR			Rapy	*Ranunculus*	*pygmaeus*	pygmy buttercup
	SR	SH		Rara	*Ranunculus*	*ranunculinus*	tadpole buttercup
	SR	SH		Rasc3	*Ranunculus*	*sceleratus*	celeryleaf buttercup
SM	SR			Raun	*Ranunculus*	*uncinatus*	hooked buttercup
			LR	Raco3	*Ratibida*	*columnifera*	upright prairie coneflower

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM				Rocu2	*Rorippa*	*curvipes*	bluntleaf yellowcress
		SH		Rois2	*Rorippa*	*islandica*	water cress
SM			LR	Ropa2	*Rorippa*	*palustris*	bog yellowcress
SM	SR			Rocu2	*Rorippa*	*curvipes*	bluntleaf yellowcress
	SR	SH	LP	Ruhi2	*Rudbeckia*	*hirta*	black-eyed Susan
SM	SR		LP	Rula3	*Rudbeckia*	*laciniata*	cutleaf coneflower
SM				Ruoc2	*Rudbeckia*	*occidentalis*	western coneflower
SM	SR			Ruac3	*Rumex*	*acetosella*	common sheep sorrel
SM				Ruaq	*Rumex*	*aquaticus*	western dock
SM	SR	SH	LR	Rucr	*Rumex*	*crispus*	curly dock
SM	SR			Rude2	*Rumex*	*densiflorus*	dense-flowered dock
E	SR			Ruma4	*Rumex*	*maritimus*	golden dock
SM		SH	LR	Ruoc3	*Rumex*	*occidentalis*	western dock
SM	SR			Rupa6	*Rumex*	*paucifolius*	fewleaved dock
SM	SR		LP	Rusa	*Rumex*	*salicifolius*	willow dock
E	SR			Sasa	*Sagina*	*saginoides*	arctic pearlwort
SM	SR			Sacu	*Sagittaria*	*cuneata*	arumleaf arrowhead
			LP	Sama2	*Sanicula*	*marilandica*	Maryland sanicle
	SR			Sace2	*Saxifraga*	*cernua*	nodding saxifrage
	SR+			Sach4	*Saxifraga*	*chrysantha*	golden saxifrage
	SR			Safl6	*Saxifraga*	*flagellaris*	whiplash saxifrage
SM	SR			Sari8	*Saxifraga*	*rivularis*	weak saxifrage
SM	SR			Saod2	*Saxifraga*	*odontoloma*	brook saxifrage
SM	SR	SH		Sarh2	*Saxifraga*	*rhomboidea*	diamondleaf saxifrage
E				Sari8	*Saxifraga*	*rivularis*	weak saxifrage
	SR			Sase7	*Saxifraga*	*serpyllifolia*	thymeleaf saxifrage
SM	SR	SH	LR	Scla	*Scrophularia*	*lanceolata*	lanceleaf figwort
E	SR	SH	LP	Scbr3	*Scuttellaria*	*brittonii*	Britton's skullcap
		SH	LP	Scga	*Scuttellaria*	*galericulata*	marsh skullcap
	SR		LR	Sein4	*Sedum*	*integrifolium*	ledge stonecrop
SM	SR	SH	LP	Sela	*Sedum*	*lanceolatum*	spearleaf stonecrop
SM	SR			Serh	*Sedum*	*rhodanthum*	redpod stonecrop
SM				Sest2	*Sedum*	*stenopetalum*	wormleaf stonecrop
SM+	SR+			Sebi2	*Senecio*	*bigelovii*	nodding ragwort
SM	SR	SH	LP	Seca2	*Senecio*	*canus*	woolly groundsel
SM	SR			Secr	*Senecio*	*crassulus*	thickleaf groundsel
	SR+			Secr2	*Senecio*	*crocatus*	saffon groundsel
	SR			Sede3	*Senecio*	*debilis*	weak groundsel
SM	SR			Sedi4	*Senecio*	*dimorphophyllus*	variflower groundsel
SM	SR			Seer2	*Senecio*	*eremophilus*	desert groundsel
SM	SR	SH		Sefe	*Senecio*	*fendleri*	Fendler's groundsel
SM	SR			Sefr3	*Senecio*	*fremontii*	Fremont's groundsel
	SR			Sehy2	*Senecio*	*hydrophilus*	water groundsel
SM	SR	SH	LR	Sein2	*Senecio*	*integerrimus*	lambstongue groundsel
SM	SR		LR	Seps2	*Senecio*	*pseudaureus*	falsegold groundsel
	SR	SH	LP	Sera	*Senecio*	*rapifolius*	openwoods groundsel
SM	SR			Sese2	*Senecio*	*serra*	butterweed groundsel
	SR			Sesp3	*Senecio*	*spartioides*	broom groundsel

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Sest3	*Senecio*	*streptanthifolius*	cleftleaf groundsel
SM	SR		LR	Setr	*Senecio*	*triangularis*	arrowleaf groundsel
SM	SR		LP	Sesw2	*Senecio*	*werneriaefolius*	hoary groundsel
SM	SR			Sipr	*Sibbaldia*	*procumbens*	creeping sibbaldia
SM+	SR+			Sica3	*Sidalcea*	*candida*	white checker-mallow
SM	SR		LP	Sine3	*Sidalcea*	*neomexicana*	New Mexican checker-mallow
	SR			Siac	*Silene*	*acaulis*	moss campion
			LP	Sian2	*Silene*	*antirrhina*	sleepy silene
SM	SR	SH	LP	Sidr	*Silene*	*drummondii*	Drummond's cockle
SM	SR			Silaa3	*Silene*	*latifolia*	bladder champion
SM	SR			Sime	*Silene*	*menziesii*	Menzie's champion
SM	SR			Sipa4	*Silene*	*parryi*	Parry's silene
			LR	Sivu	*Silene*	*vulgaris*	maiden's tears
SM				Sial2	*Sisymbrium*	*altissimum*	tall tumblemustard
SM				Siid	*Sisyrinchium*	*idahoense*	Idaho blue-eyedgrass
SM		SH	LP	Simo2	*Sisyrinchium*	*montanum*	mountain blue-eyedgrass
	SR			Susu2	*Sium*	*suave*	hemlock waterparsnip
			LR	Smla3	*Smilax*	*lasioneura*	smilax
SM				Sotr	*Solanum*	*triflorum*	cutleaf nightshade
SM	SR		LP	Soca6	*Solidago*	*canadensis*	Canada goldenrod
SM	SR	SH	LR	Sogi	*Solidago*	*gigantea*	giant goldenrod
SM	SR	SH	LP	Somi2	*Solidago*	*missouriensis*	Missouri goldenrod
	SR			Somu	*Solidago*	*multiradiata*	mountain goldenrod
	SR			Sona	*Solidago*	*nana*	baby goldenrod
SM	SR		LR	Sopa4	*Solidago*	*parryi*	Parry's goldenrod
SM	SR			Sosi3	*Solidago*	*simplex*	Mt. Albert goldenrod
SM	SR		LP	Sosp5	*Solidago*	*sparsiflora*	fewflower goldenrod
SM	SR	SH	LP	Sosp	*Solidago*	*spathulata*	spoonleaf goldenrod
E	SR			Soul5	*Sonchus*	*ulignosus*	marsh sowthistle
SM	SR	SH		Span2	*Sparganium*	*angustifolium*	narrowleaved burweed
	SR			Spmi	*Sparganum*	*minimum*	small burweed
SM	SR			Spru	*Spergularia*	*rubra*	red sandspurry
SM	SR			Spco	*Sphaeralcea*	*coccinea*	scarlet globemallow
SM	SR			Spro	*Spiranthes*	*romanzoffiana*	hooded ladiestresses
E	SR	SH	LR	Stpa	*Stachys*	*palustris*	marsh hedgenettle
SM				Stbo3	*Stellaria*	*borealis*	boreal starwort
E	SR			Stca	*Stellaria*	*calycantha*	northern starwort
E	SR			Stcr	*Stellaria*	*crassifolia*	fleshy starwort
E	SR	SH		Stlo	*Stellaria*	*longifolia*	longleaf starwort
SM	SR		LR	Stlo2	*Stellaria*	*longipes*	longstalk starwort
	SR			Stmo2	*Stellaria*	*monantha*	chickweed
E				Stob	*Stellaria*	*obtusa*	Rocky mountain chickweed
SM	SR			Stum	*Stellaria*	*umbellata*	umbrella starwort
			LP	Stte2	*Stephanomeria*	*tenuifolia*	narrowleaf wirelettuce
SM	SR	SH	LP	Stam2	*Streptopus*	*amplexifolius*	claspleaf twistedstalk
SM	SR	SH		Swpe	*Swertia*	*perennis*	star gentian
		SH+		Tapa3	*Talinum*	*parviflorum*	sunbright
E				Tavu	*Tanacetum*	*vulgare*	common tansy

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
E	SR			Tace	*Taraxacum*	*ceratophorum*	rough dandelion
E	SR			Taer2	*Taraxacum*	*eriophorum*	woolbearing dandelion
	SR			Tala2	*Taraxacum*	*laevigatum*	rock dandelion
SM	SR			Taly	*Taraxacum*	*lyratum*	harp dandelion
SM	SR	SH	LP	Taof	*Taraxacum*	*officinale*	common dandelion
SM	SR			Teca2	*Tetradymia*	*canescens*	spineless horsebrush
SM	SR			Thal	*Thalictrum*	*alpinum*	alpine meadowrue
SM	SR	SH	LP	Thfe	*Thalictrum*	*fendleri*	Fendler's meadowrue
SM				Thoc	*Thalictrum*	*occidentale*	western meadowrue
SM	SR			Thsp	*Thalictrum*	*sparsiflorum*	fewflowered meadowrue
SM	SR		LR	Thve	*Thalactrum*	*venulosum*	veiny meadowrue
E				Thsa2	*Thelypodium*	*sagittatum*	arrow thelypody
E	SR	SH	LR	Thmo6	*Thermopsis*	*montana*	mountain thermopsis
SM	SR			Thar5	*Thlaspi*	*arvense*	fieldpennycress
SM	SR			Thmo5	*Thlaspi*	*montanum*	alpine pennycress
SM	SR	SH		Toho	*Townsendia*	*hookeri*	Hooker's townsendia
SM	SR	SH	LP	Trdu	*Tragopogon*	*dubius*	common salsify
SM				Trpr	*Tragopogon*	*pratensis*	meadow salsify
SM	SR	SH	LP	Trda2	*Trifolium*	*dasyphyllum*	alpine clover
SM				Trgy	*Trifolium*	*gymnocarpon*	holly-leaf clover
SM	SR	SH	LP	Trhy	*Trifolium*	*hybridum*	alsike clover
SM	SR			Trlo	*Trifolium*	*longipes*	longstalk clover
SM	SR			Trpa5	*Trifolium*	*parryi*	Parry's clover
SM	SR	SH	LR	Trpr2	*Trifolium*	*pratense*	red clover
SM	SR	SH		Trre3	*Trifolium*	*repens*	white clover
SM+				Trov2	*Trillium*	*ovatum*	Pacific trillium
SM	SR		LR	Trla14	*Trollius*	*laxus*	American globeflower
	SR			Tyla	*Typha*	*latifolia*	broadleaf cattail
SM	SR		LR	Urdi	*Urtica*	*dioica*	stinging nettle
	SR			Utvu	*Utricularia*	*vulgaris*	common bladderwort
	SR			Vaac	*Valeriana*	*acutiloba*	sharpleaf valerian
SM	SR	SH		Vaed	*Valeriana*	*edulis*	edible valerian
SM	SR		LP	Vaoc2	*Valeriana*	*occidentalis*	western valerian
SM+				Vete4	*Veratrum*	*tenuipetalum*	Colorado false-hellebore
	SR			Veth	*Verbascum*	*thapsus*	common mullein
E	SR		LP	Vebr	*Verbena*	*bracteata*	bigbract verbena
	SR			Vest	*Verbena*	*stricta*	hoary verbena
SM	SR	SH		Veam2	*Veronica*	*americana*	American speedwell
	SR	SH	LP	Vepe2	*Veronica*	*peregrina*	neckweed
SM	SR			Vese	*Veronica*	*serpyllifolia*	thymeleaf speedwell
SM	SR			Vewo2	*Veronica*	*wormskjoldii*	American alpine speedwell
SM	SR	SH	LP	Viam	*Vicia*	*americana*	American vetch
SM	SR			Vimun	*Viguiera*	*multiflora*	viguiera
SM	SR		LR	Viad	*Viola*	*adunca*	hookedspur violet
SM	SR	SH	LR	Vica4	*Viola*	*canadensis*	Canadian white violet
	SR			Vima2	*Viola*	*macloskyi*	small white violet
SM	SR	SH		Vine	*Viola*	*nephrophylla*	northern bog violet
SM	SR			Vinu2	*Viola*	*nuttallii*	Nuttall's violet

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR			Vipa4	*Viola*	*palustris*	marsh violet
SM	SR			Vipr3	*Viola*	*praemorsa*	canary violet
SM				Vipu4	*Viola*	*purpurea*	goosefoot violet
SM	SR			Viva	*Viola*	*vallicola*	valley violet
SM	SR		LR	Wyam	*Wyethia*	*amplexicaulis*	mulesears wyethia
	SR			Xygl	*Xylorhiza*	*glabriuscula*	smooth woody aster
SM	SR	SH	LR	Ziel2	*Zigadenus*	*elegans*	mountain deathcamas
SM	SR	SH		Zive	*Zigadenus*	*venenosus*	meadow deathcamas
SM	SR	SH		Ziap	*Zizia*	*aptera*	mountain zizia
					GRASSES and other GRAMINOIDS		
E	SR			Agcr	*Agropyron*	*cristatum*	crested wheatgrass
		SH		Agde2	*Agropyron*	*desertorum*	desert wheatgrass
	SR			Agbo2	*Agrostis*	*borealis*	arctic bentgrass
SM	SR		LR	Agex	*Agrostis*	*exarata*	spike bentgrass
	SR			Aghu	*Agrostis*	*humilis*	alpine bentgrass
E	SR			Agid	*Agrostis*	*idahoensis*	Idaho bentgrass
SM	SR	SH	LP	Agsc5	*Agrostis*	*scabra*	rought bentgrass
SM	SR		LR	Agst2	*Agrostis*	*stolonifera*	creeping bentgrass
	SR			Agth2	*Agrostis*	*thurberiana*	Thurber's bentgrass
SM	SR			Agva	*Agrostis*	*variabilis*	mountain bentgrass
SM	SR	SH	LR	Alae	*Alopecurus*	*aequalis*	shortawn foxtail
SM	SR			Alal2	*Alopecurus*	*alpinus*	alpine foxtail
	SR			Alpr3	*Alopecurus*	*pratensis*	meadow foxtail
	SR			Arpu9	*Aristida*	*purpurea*	purple threeawn
SM	SR	SH		Besy	*Beckmannia*	*syzigachne*	American sloughgrass
SM	SR		LP	Bogr2	*Bouteloua*	*gracilis*	blue grama
SM	SR		LR	Bran	*Bromus*	*anomalus*	nodding brome
SM	SR	SH	LR	Brca5	*Bromus*	*carinatus*	rattlesnake brome
SM	SR	SH	LP	Brci2	*Bromus*	*ciliatus*	fringed brome
SM	SR		LP	Brin2	*Bromus*	*inermis*	smooth brome
SM	SR			Brja	*Bromus*	*japonicus*	Japanese brome
SM				Brpo	*Bromus*	*polyanthus*	brome
SM	SR			Brte	*Bromus*	*tectorum*	cheatgrass
SM	SR		LR	Caca4	*Calamagrostis*	*canadensis*	bluejoint reedgrass
	SR		LR	Cain	*Calamagrostis*	*inexpansa*	northern reedgrass
SM				Camo	*Calamagrostis*	*montanensis*	plains reedgrass
E	SR		LP	Capu	*Calamagrostis*	*purpurascens*	pruple reedgrass
SM	SR			Caru	*Calamagrostis*	*rubescens*	pinegrass
	SR			Cast13	*Calamagrostis*	*stricta*	reedgrass
SM	SR	SH		Caaq3	*Catabrosa*	*aquatica*	water whorlgrass
SM	SR			Cila2	*Cinna*	*latifolia*	drooping woodreed
SM	SR			Dagl	*Dactylis*	*glomerata*	orchardgrass
E	SR			Daca3	*Danthonia*	*californica*	California oatgrass
SM	SR		LR	Dain	*Danthonia*	*intermedia*	timber oatgrass
		SH	LR	Dapa2	*Danthonia*	*parryi*	Parry's danthonia
			LP	Dasp2	*Danthonia*	*spicata*	poverty danthonia

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
	SR		LP	Deat2	*Danthonia*	*unispicata*	onespike danthonia
	SR			Deca18	*Deschampsia*	*atropurpurea*	mountain hairgrass
SM	SR	SH	LR	Dece	*Deschampsia*	*caespitosa*	tufted hairgrass
			LP+	Dili2	*Dicanthelium*	*linearifolium*	slimleaf panicum
	SR			Ellaa	*Elymus*	*albicans*	wildrye
SM	SR		LR	Elca4	*Elymus*	*canadensis*	Canada wildrye
SM	SR		LR	Elci2	*Elymus*	*cinereus*	basin wildrye
SM	SR	SH	LP	Elel5	*Elymus*	*elymoides*	bottlebrush squirreltail
SM	SR		LR	Elgl	*Elymus*	*glaucus*	blue wildrye
	SR			Elhi6	*Elymus*	*hispidus*	intermediate wheatgrass
	SR			Elje	*Elymus*	*junceus*	Russian wildrye
	SR	SH		ella3	*Elymus*	*lanceolatus*	streamband wheatgrass
E	SR			Elma9	*Elymus x*	*macounii*	Macoun wildrye
	SR		LR	Elre4	*Elymus*	*repens*	quackgrass
SM	SR			Elsc4	*Elymus*	*scribneri*	spreading wheatgrass
SM	SR	SH	LR	Eltr7	*Elymus*	*trachycaulus*	slender wheatgrass
SM	SR			Febr	*Festuca*	*brachyphylla*	alpine fescue
	SR*+			Feha3	*Festuca*	*hallii*	plains rough fescue
SM	SR	SH	LP	Feid	*Festuca*	*idahoensis*	Idaho fescue
SM				Fepr	*Festuca*	*pratensis*	meadow fescue
	SR		LR	Feru2	*Festuca*	*rubra*	red fescue
SM	SR	SH		Fesa	*Festuca*	*saximontana*	Rocky Mountain fescue
	SR			Feth	*Festuca*	*thurberi*	Thurber's fescue
E				Glbo	*Glyceria*	*borealis*	northern mannagrss
SM	SR		LP	Glel	*Glyceria*	*elata*	tall mannagrass
SM	SR	SH		Glgr	*Glyceria*	*grandis*	American mannagrass
SM	SR	SH	LR	Glst	*Glyceria*	*striata*	fowl mannagrass
	SR			Hiod	*Hierochloe*	*odorata*	sweetgrass
SM	SR	SH	LR	Hobr2	*Hordeum*	*brachyantherum*	meadow barley
	SR			Hoca9	*Hordeum*	*caespitosum*	bobtail barley
SM	SR			Hoju	*Hordeum*	*jubatum*	foxtail barley
E	SR			Hopu	*Hordeum*	*pusillum*	little barley
SM	SR	SH	LP	Koma	*Koeleria*	*macrantha*	prairie Junegrass
SM	SR	SH	LP	Leki2	*Leucopoa*	*kingii*	king spikefescue
SM	SR			Mebu	*Melica*	*bulbosa*	oniongrass
SM	SR			Mesp	*Melica*	*spectabilis*	purple oniongrass
			LP	Mesu	*Melica*	*subulata*	Alaska oniongrass
E				Muan	*Muhlenbergia*	*andina*	foxtail muhly
	SR	SH		Mufi	*Muhlenbergia*	*filiculmis*	slimstem muhly
SM	SR			Mufi2	*Muhlenbergia*	*filiformis*	pullup muhly
E	SR			Muri	*Muhlenbergia*	*richardsonis*	mat muhly
	SR		LP	Oras	*Oryzopsis*	*asperifolia*	roughleaf ricegrass
SM	SR	SH	LP	Orex	*Oryzopsis*	*exigua*	little ricegrass
SM	SR		LP	Orhy	*Oryzopsis*	*hymenoides*	Indian ricegrass
E	SR		LP	Ormi2	*Oryzopsis*	*micrantha*	littleseed ricegrass
SM		SH	LR	Pasm	*Pascopyrum*	*smithii*	western wheatgrass
E	SR		LR	Phar3	*Phalaris*	*arundinacea*	reed canarygrass
SM	SR	SH	LR	Phal2	*Phleum*	*alpinum*	alpine timothy

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM	SR	SH	LP	Phpr3	*Phleum*	*pratense*	timothy
SM	SR			Poal2	*Poa*	*alpina*	alpine bluegrass
	SR	SH		Poan	*Poa*	*annua*	annual bluegrass
	SR			Poar2	*Poa*	*arctica*	artic bluegrass
E				Poar3	*Poa*	*arida*	plains bluegrass
SM		SH	LP	Poco	*Poa*	*compressa*	Canada bluegrass
SM	SR			Pocu3	*Poa*	*cusickii*	Cusick bluegrass
SM	SR	SH	LR	Pofe	*Poa*	*fendleriana*	muttongrass
			LR	Poglg2	*Poa*	*glaucantha*	upland bluegrass
	SR		LR	Pogl3	*Poa*	*glaucifolia*	swollen bluegrass
SM	SR		LP	Poin	*Poa*	*interior*	inland bluegrass
SM	SR			Poju	*Poa*	*juncifolia*	alkali bluegrass
	SR		LR	Pole2	*Poa*	*leptocoma*	bog bluegrass
SM	SR	SH	LP	Pone2	*Poa*	*nervosa*	Wheeler bluegrass
SM				Pone3	*Poa*	*nevadensis*	Nevada bluegrass
SM	SR	SH	LR	Popa2	*Poa*	*palustris*	fowl bluegrass
E	SR			Popa3	*Poa*	*pattersonii*	Patterson bluegrass
SM	SR	SH	LP	Popr	*Poa*	*pratensis*	Kentucky bluegrass
SM	SR			Pore	*Poa*	*reflexa*	nodding bluegrass
E	SR			Poru10	*Poa*	*rupicola*	timberline bluegrass
SM	SR	SH		Pose	*Poa*	*secunda*	Sandberg bluegrass
SM	SR	SH	LP	Pssps	*Pseudoroegnaria*	*spicata*	bluebunch wheatgrass
SM	SR			Pupah	*Puccinellia*	*pauciflora*	alkali-grass
E				Spob	*Sphenopholis*	*obtusata*	prairie wedgescale
	SR			Spcr	*Sporobolus*	*cryptandrus*	sand dropseed
SM	SR	SH	LP	Stco4	*Stipa*	*comata*	needleandthread
SM	SR		LP	Stle4	*Stipa*	*lettermanii*	letterman needlegrass
SM	SR	SH	LP	Stne3	*Stipa*	*nelsonii*	Nelson's needlegrass
	SR			Stoc2	*Stipa*	*occidentalis*	western needlegrass
SM				Stpi2	*Stipa*	*pinetorum*	pine needlegrass
SM	SR	SH		Stri2	*Stipa*	*richardsonii*	Richardson's needlegrass
			LR	Stro3	*Stipa*	*robusta*	sleepygrass
			LP	Stvi4	*Stipa*	*viridula*	green needlegrass
		SH		Topa6	*Torreyochloa*	*pallida*	Fernald's false-manna grass
SM	SR		LR	Trsp2	*Tristeum*	*spicatum*	spike trisetum
SM	SR			Trwo3	*Trisetum*	*wolfii*	Wolf's trisetum
	SR			Caal6	*Carex*	*albonigra*	blackandwhite scaled sedge
SM	SR	SH	LR	Caaq	*Carex*	*aquatilis*	water sedge
SM	SR		LP	Caat3	*Carex*	*athrostachya*	slenderbeak sedge
SM	SR		LP	Caat5	*Carex*	*atrata*	black sedge
SM	SR	SH	LR	Caau3	*Carex*	*aurea*	golden sedge
			LR	Cabr10	*Carex*	*brevior*	fescue sedge
	SR			Cabr15	*Carex*	*brunnescens*	brownish sedge
SM	SR	SH	LP	Caca11	*Carex*	*canescens*	silvery sedge
	SR			Caca12	*Carex*	*capillaris*	hairlike sedge
SM				Caca13	*Carex*	*capitata*	capitate sedge
	SR+			Cadi4	*Carex*	*diandra*	lesserpanicled sedge
	SR		LR	Cadi6	*Carex*	*disperma*	softleaved sedge

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
SM				Cado2	*Carex*	*douglasii*	Douglas sedge
		SH		Cadu6	*Carex*	*duriscula*	needleleaf sedge
SM	SR			Caeb	*Carex*	*ebenea*	ebony sedge
SM+	SR+			Caeg	*Carex*	*egglestonii*	Eggleston's sedge
SM	SR			Cael3	*Carex*	*elynoides*	blackroot sedge
SM				Cafi	*Carex*	*filifolia*	threadleaf sedge
E	SR	SH	LR	Cafo3	*Carex*	*foena*	dry spike sedge
	SR			Cafo8	*Carex*	*foetida*	sedge
SM	SR		LP	Cage2	*Carex*	*geyeri*	elk sedge
SM+	SR+			Cagy2	*Carex*	*gynocrates*	northern bog sedge
SM	SR			Caha6	*Carex*	*haydeniana*	cloud sedge
SM	SR		LP	Caho5	*Carex*	*hoodii*	Hood's sedge
SM	SR			Cail	*Carex*	*illota*	sheep sedge
E			LP	Cain11	*Carex*	*interior*	inland sedge
	SR	SH		Cainh2	*Carex*	*inops*	sun sedge
E	SR		LR	Cajo	*Carex*	*jonesii*	Jone's sedge
SM		SH	LR	Cala30	*Carex*	*lanuginosa*	woolly sedge
SM	SR			Cale8	*Carex*	*lenticularis*	tufted sedge
SM+				Cali7	*Carex*	*limosa*	mud sedge
	SR			Cama9	*Carex*	*macloviana*	thickhead sedge
SM	SR	SH	LR	Cami7	*Carex*	*microptera*	smallwing sedge
	SR			Cana2	*Carex*	*nardina*	spikesedge
SM	SR	SH	LP	Cane2	*Carex*	*nebrascensis*	Nebraska sedge
E	SR			Cane3	*Carex*	*nelsonii*	Nelson's sedge
SM	SR			Cane6	*Carex*	*neurophora*	alpinenerved sedge
SM	SR			Cani2	*Carex*	*nigricans*	black alpine sedge
SM	SR			Cano2	*Carex*	*norvegica*	Norway sedge
E	SR			Cano3	*Carex*	*nova*	black sedge
SM+	SR+			Caoc2	*Carex*	*occidentalis*	western sedge
	SR+	SH+		Caor	*Carex*	*oreocharis*	grassy slope sedge
SM	SR		LR	Capa14	*Carex*	*pachystachya*	chamisso sedge
	SR+			Capa22	*Carex*	*paupercula*	little sedge
	E			Capa18	*Carex*	*parryana var unica*	Parry's sedge
	SR			Capa31	*Carex*	*paysonis*	Payson's sedge
SM	SR			Cape6	*Carex*	*pensylvanica*	Pennsylvania sedge
SM		SH	LP	Cape7	*Carex*	*petasata*	Loddon sedge
SM	SR		LP	Caph2	*Carex*	*phaeochephala*	dunhead sedge
SM	SR			Capr4	*Carex*	*praeceptorum*	early sedge
SM	SR			Capr5	*Carex*	*praegracilis*	clustered field sedge
SM	SR			Capy3	*Carex*	*pyrenaica*	Pyrenean sedge
SM	SR		LR	Cara6	*Carex*	*raynoldsii*	Raynold's sedge
SM	SR		LP	Caro5	*Carex*	*rossii*	Ross' sedge
SM	SR	SH	LP	Caro6	*Carex*	*rostrata*	beaked sedge
	SR			Caru3	*Carex*	*rupestris*	rock sedge
		SH+		Casa8	*Carex*	*sartwellii*	Sartwell's sedge
SM	SR			Casa10	*Carex*	*saxatilis*	rock sedge
SM	SR			Casc12	*Carex*	*scopulorum*	mountain sedge
		SH		Casi2	*Carex*	*simulata*	analogue sedge

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
			LR	Casp7	*Carex*	*sprengelii*	Sprengel's sedge
SM	SR			Cast40	*Carex*	*stenophylla*	sedge
			LP	Cate3	*Carex*	*tenera*	quill sedge
SM	SR			Cava3	*Carex*	*vallicola*	valley sedge
SM	SR			Cave6	*Carex*	*vesicaria*	blister sedge
SM			LR	Caxe	*Carex*	*xerantica*	whitescale sedge
		SH	LR	Elac	*Eleocharis*	*acicularis*	needle spikesedge
SM	SR	SH	LR	Elpa3	*Eleocharis*	*palustris*	common spikerush
SM	SR			Elqu2	*Eleocharis*	*quinqueflora*	fewflower spikerush
	SR	SH		Eran6	*Eriophorum*	*polystachion*	narrowleaf cottonsedge
	SR			Jual2	*Juncus*	*albescens*	northern white rush
SM	SR	SH		Jual4	*Juncus*	*alpinoarticulatus*	northern green rush
SM	SR	SH	LP	Juba	*Juncus*	*balticus*	Baltic rush
	SR			Juca6	*Juncus*	*castaneus*	chestnut rush
SM	SR	SH	LP	Juco2	*Juncus*	*confusus*	Colorado rush
SM	SR			Judr	*Juncus*	*drummondii*	Drummond's rush
SM	SR		LP	Juen	*Juncus*	*ensifolius*	swordleaf rush
SM+				Jufi	*Juncus*	*filiformis*	thread rush
SM	SR			Juha	*Juncus*	*hallii*	Hall's rush
SM			LR	Juin2	*Juncus*	*interior*	inland rush
SM	SR	SH	LP	Julo	*Juncus*	*longistylis*	longstyle rush
SM	SR			Jume3	*Juncus*	*mertensianus*	Merten's rush
			LR	June	*Juncus*	*nevadensis*	Nevada rush
SM			LR	Juno2	*Juncus*	*nodosus*	jointed rush
SM	SR			Jupa	*Juncus*	*parryi*	Parry's rush
	SR	SH	LP	Jusa	*Juncus*	*saximontanus*	Rocky Mountain rush
			LR	Jute	*Juncus*	*tenuis*	poverty rush
		SH		Jutr	*Juncus*	*tracyi*	Tracy's rush
	SR+			Jutr4	*Juncus*	*triglumis*	three-hulled rush
SM				Lumu2	*Luzula*	*multiflora*	common woodrush
SM	SR		LP	Lupa4	*Luzula*	*parviflora*	smallflowered woodrush
SM	SR			Lusp4	*Luzula*	*spicata*	spike woodrush
SM				Scava	*Scirpus*	*acutus*	hardstem bulrush
SM		SH	LP	Scmi2	*Scirpus*	*microcarpus*	panicled bulrush
		SH		Trma4	*Triglochin*	*maritima*	seaside arrowgrass
				Trpa6	*Triglochin*	*palustre*	marsh arrowgrass

FERNS NON-VASCULAR PLANTS

	SR		LP	Asse	*Asplenium*	*septentrionale*	forked spleenwort
		SH		Astr2	*Asplenium*	*trichomanes*	maidenhair spleenwort
	SR+			Astr10	*Asplenium*	*trichomanes-ramosum*	brightgreen spleenwort
	SR+			Atam	*Athyrium*	*americanum*	alpine lady-fern
SM				Atfi	*Athyrium*	*filix-femina*	common ladyfern
	SR+			Bolu	*Botrychium*	*lunaria*	common moonwort
SM+				Bomu	*Botrychium*	*multifidum*	leathery grapefern
SM	SR			Crac3	*Cryptogramma*	*acrostichoides*	American rockbrake
SM	SR	SH	LP	Cyfr2	*Cystopteris*	*fragilis*	brittle bladderfern

SM	SR	SH	LP	ACRO	GENUS	SPECIES	COMMON NAME
	SR	SH	LP	Drfi2	*Dryopteris*	*filix-mas*	malefern
SM	SR	SH	LP	Eqar	*Equisetum*	*arvense*	field horsetail
SM	SR	SH	LP	Eqhy	*Equisetum*	*hyemale*	scouringrush horsetail
SM	SR	SH		Eqla	*Equisetum*	*laevigatum*	smooth horsetail
SM+				Gydr	*Gymnocarpium*	*dryopteris*	western oak fern
	SR			Isbo	*Isoetes*	*bolanderi*	Bolander's quillwort
	SR			Pebr4	*Pellaea*	*breweri*	Brewer's cliffbrake
	SR			Peoc	*Pellaea*	*occidentalis*	western dwarf cliffbrake
	SR	SH		Pohe3	*Polypodium*	*hesperium*	western polypody
	SR	SH		Posa19	*Polypodium*	*saximontanum*	Rocky Mountain polypody
E				Polo4	*Polystichum*	*lonchitis*	northern hollyfern
SM	SR		LP	Ptaq	*Pteridium*	*aquilinum*	western bracken fern
SM	SR	SH	LP	Sede2	*Selaginella*	*densa*	lesser spikemoss
	SR+			Semu	*Selaginella*	*mutica*	bluntleaf spikemoss
		SH		Seun	*Selaginella*	*underwoodii*	Underwood's spikemoss
E	SR		LP	Woor	*Woodsia*	*oregana*	Oregon woodsia
SM	SR		LP	Wosc	*Woodsia*	*scopulina*	Rocky Mountain woodsia

APPENDIX 5

EXOTIC PLANT SPECIES ON THE MEDICINE BOW NATIONAL FOREST

There are relatively few exotic plants recorded on the Medicine Bow National Forest in comparison to the numerous species of plants which are believed to have been resident on the landscape for several millenia. Exotic, in this report, refers to plant species which have been introduced into the area in the last two centuries. These species are mostly from Europe or Asia but some may be from other parts of North America (Table AP5.1). It is likely that these species would not occur on the Medicine Bow National Forest in the absence of human assistance to bring seeds or propagules to the area.

There are probably additional species, or recorded species may be more widespread than these data indicate, because most floristic surveys (which are the basis for these data) emphasize native species and may not include introduced plants.

The exotic species include one shrub, fifty-five forbs and fifteen grasses. Most occur at low elevations on disturbed ground in either uplands or riparian areas. Eight forbs and one grass are on the Wyoming Weed and Pest Control Act Designated List (Wyoming Department of Agriculture, 1973). These plants are considered by the State of Wyomning to be detrimental to the welfare of persons residing in state weed and pest control districts (Table AP5.2).

The areas of the Medicine Bow National Forest which are most likely to contain populations of these species are the southern Laramie Mountains and lower elevations in the Sierra Madre, especially on the western side. The Sherman Mountains, Medicine Bow Mountains and most of the Sierra Madre Mountains are too high, dry and cold, or lack suitable soils, to be prime habitat for these species. The exception is riparian areas.

Integrated pest management is the Proposed Action recommended in the **Programatic Assessment for Undesireable Plant Control** (Chesbro, 1992) on the Medicine Bow National Forest. This policy permits a variety of control methods to be used to control undesireable plants. Separate Envrionmental Assessments are done for specific weed control projects at the District level.

Canada thistle and musk thistle are the major species which have received attention for noxious weed control by the Districts of the Medicine Bow Natioanl Forest. Site-specific application of herbicide, use of beetle larvae (weevils) and sawfly parasites (as biological control agents), and mechanical control (removal of

Spraying of herbicide is used less now than in the past. Effects of using hebicides on other broad-leafed species have never been evaluated, thus the effects of chemical control on biological diversity are unknown.

In the Sierra Madre, yellow toadflax control has become increasingly important. Spotted knapweed has recently been found in the Sierra Madre and has been controlled by removing individual plants (Haas, 1994). Russian olive has not yet been reported for the area although it is common in riparian areas near the Forest boundary.

Other species have not been sufficiently aggressive, or have not caused sufficient degradation of desired resource values to require control.

LITERATURE CITED

Wyoming Department of Agriculture. 1973. Wyoming Weed and Pest Control Act of 1973. Title 11, Chapter 5

Chesbro, W.C. 1992. **Programmatic Environmental Assessment for Undesireable Plant Control on the Medicine Bow National Forest** Medicine Bow National Forest Laramie, WY

Haas, W. 1994. Personal communication. Range Conservationist, Hayden Ranger District

TABLE AP5.1 EXOTIC PLANT SPECIES FOUND ON THE MEDICINE BOW NATIONAL FOREST

SM	SR	SH	LP	GENUS	SPECIES	COMMON NAME
					SHRUBS	
	SR			*Lonicera*	*tatarica*	Tatarian honeysuckle
					FORBS	
SM				*Alyssum*	*alyssoides*	pale madwort
SM	SR			*Alyssum*	*desertorum*	desert madwort
	SR			*Alyssum*	*parviflorum*	European madwort
	SR			*Amaranthus*	*retroflexus*	redroot pigweed
SM	SR			*Barbarea*	*vulgaris*	garden yellowrocket
SM				*Berteroa*	*incana*	hoary false madwort
SM				*Camelina*	*microcarpa*	littlepod falseflax
SM	SR			*Capsella*	*bursa-pastoris*	shepherd's purse
SM	SR			*Carduus*	*nutans*	nodding plumeless thistle
SM	SR			*Cerastium*	*fontanum*	chickweed
SM				*Chenopodium*	*rubrum*	red goosefoot
SM				*Chorispora*	*tenella*	crossflower
SM	SR			*Chrysanthemum*	*leucanthemum*	chyrsanthemum
SM	SR	SH	LP	*Cirsium*	*arvense*	Canadian thistle
SM				*Cirsium*	*vulgare*	bull thistle
			LR	*Conium*	*maculatum*	poison hemlock
	SR			*Cynoglossum*	*officinale*	gypsy flower
SM	SR			*Descurania*	*sophia*	herb sophia
SM		SH		*Draba*	*nemorosa*	woodland whitlowgrass
SM				*Erodium*	*cicutarium*	redstem storksbill
	SR		LP	*Euphorbia*	*esula*	wolf's milk
	SR		LR	*Gnaphalium*	*uliginosum*	marsh cudweed
SM	SR			*Hesperis*	*matronalis*	dames rocket
SM	SR			*Lepidium*	*densiflorum*	common pepperweed
SM				*Lepidium*	*perfoliatum*	clasping pepperweed
	SR	SH		*Linaria*	*dalmatica*	dalmatian toadflax
SM	SR			*Linaria*	*vulgaris*	butter and eggs
SM				*Malva*	*neglecta*	cheeseweed mallow
			LP	*Marrubium*	*vulgare*	common horehound
SM	SR	SH		*Medicago*	*lupulina*	black medic
	SR			*Medicago*	*sativa*	alfalfa
	SR			*Melilotus*	*albus*	white sweetclover
	SR			*Melilotus*	*officinalis*	yellow sweetclover
SM				*Plantago*	*major*	common plantain
SM	SR	SH		*Polygonum*	*aviculare*	prostrate knotweed
	SR			*Polygonum*	*ramosissimum*	bushy knotweed
	SR	SH	LR	*Potentilla*	*norvegica*	Norweigian cinquefoil
SM	SR			*Rumex*	*acetosella*	common sheep sorrel
SM	SR	SH	LR	*Rumex*	*crispus*	curly dock
SM	SR			*Silene*	*latifolia*	bladder champion
			LR	*Silene*	*vulgaris*	maiden's tears

SM				*Sisymbrium*	*altissimum*	tall tumblemustard
E	SR			*Sonchus*	*ulignosus*	marsh sowthistle
SM	SR			*Spergularia*	*rubra*	red sandspurry
E				*Tanacetum*	*vulgare*	common tansy
	SR			*Taraxacum*	*laevigatum*	rock dandelion
SM	SR	SH	LP	*Taraxacum*	*officinale*	common dandelion
SM	SR			*Thlaspi*	*arvense*	fieldpennycress
SM	SR	SH	LP	*Tragopogon*	*dubius*	common salsify
SM			LP	*Tragopogon*	*pratensis*	meadow salsify
SM	SR	SH	LP	*Trifolium*	*hybridum*	alsike clover
SM	SR	SH	LR	*Trifolium*	*pratense*	red clover
SM	SR	SH		*Trifolium*	*repens*	white clover
	SR			*Verbascum*	*thapsus*	common mullein
				GRASSES and other GRAMINOIDS		
E	SR			*Agropyron*	*cristatum*	crested wheatgrass
SM	SR		LR	*Agrostis*	*stolonifera*	creeping bentgrass
	SR			*Alopecurus*	*pratensis*	meadow foxtail
SM	SR		LP	*Bromus*	*inermis*	smooth brome
SM	SR			*Bromus*	*japonicus*	Japanese brome
SM	SR			*Bromus*	*tectorum*	cheatgrass
SM	SR			*Dactylis*	*glomerata*	orchardgrass
	SR			*Elymus*	*hispidus*	intermediate wheatgrass
	SR			*Elymus*	*junceus*	Russian wildrye
	SR		LR	*Elymus*	*repens*	quackgrass
SM				*Festuca*	*pratensis*	meadow fescue
SM	SR	SH	LP	*Phleum*	*pratense*	timothy
	SR	SH		*Poa*	*annua*	annual bluegrass
SM		SH	LP	*Poa*	*compressa*	Canada bluegrass
SM	SR	SH	LP	*Poa*	*pratensis*	Kentucky bluegrass

TABLE AP5.2 EXOTIC SPECIES WHICH ARE ALSO DESIGNATED WEEDS

FORBS:	
Carduus nutans	musk thistle*
Centaurea bieberstenii	spotted knapweed**
Cirsium arvense	Canada thistle
Chrysanthemum leucantheumum	ox-eye daisy
Cynoglossum officinale	houndstongue
Euphorbia esula	leafy spurge
Linaria dalmatica	Dalmation toadflax
Linaria vulgaris	yellow toadflax
GRASSES:	
Agropyron repens	quackgrass

* Common names here are used by the Wyoming Department of Agriculture, 1973. They may differ from the common names listed in Appendix 4 (Plant species of the Medicine Bow National Forest).

** spotted knapweed is named *C. masulosa* in Wyoming Department of Agriculture (1973). It has not been documented for the Medicine Bow National Forest using the literature documentation methods to create Appendix 4. Hayden District personnel report that it has recently been found in the southwestern Sierra Madre Mountains (Haas, 1994).

APPENDIX 6

PLANT COMMUNITY DIVERSITY OF THE MEDICINE BOW NATIONAL FOREST

CLASSIFICATION

The classification used here is simple and is based on physiognomy, vegetative cover, and habitat (upland vs riparian).

CONIFEROUS FOREST (CF)
- Upland
- Riparian

DECIDUOUS FOREST (DF)
- Upland
- Riparian

CONIFEROUS WOODLAND (CW)
- Upland

DECIDUOUS WOODLAND (DW)
- Upland

SHRUBLAND NON-WILLOW (SHNW)
- Upland
- Riparian

SHRUBLAND WILLOW (SHW)
- Riparian

FORBLAND (FO)
- Upland
- Riparian

GRASSLAND (GRS) (True grasses)
- Upland
- Riparian

GRASSLAND (GRM) (Non-grass graminoids)
- Upland
- Riparian

Two publications list or define mainly upland plant communities on the Medicine Bow National Forest. These are:

Alexander, R.R., Hoffmann, G.R. and J.M. Wirsing. 1986. **Forest Vegetation of the Medicine Bow National Forest in Southeastern WY: A Habitat Type Classification.** Research Paper RM-271 RMFRES Fort Collins, CO

Johnston, B.C. 1987. **Plant Associations of Region 2.** R2-ECOL-87-2 Denver, CO

The publication by Alexander et al (1986) is a USDA General Technical Report. The field work was done by Wirsing as a Master's Thesis in SE Wyoming at Washington State University in 1973. Johnston (1987) used existing literature as a source for listing plant communities (Plant Associations) for all Region 2 National Forests. At the time, there were few descriptions of riparian habitats.

The list of community types for the Medicine Bow National Forest presented in Table AP6.1 is a synthesis of described community types, assembled by Judy von Ahlefeldt, Forest Ecologist, based on the following sources. It is a working list, subject to field verification. It is based on the presence of documented Medicine Bow National Forest species, field observation and published descriptions from other areas in the Rocky Mountains. The list contains both "climax" communities in the Clementsian/Daubenmire use of the term, and seral communities which are common and widespread as described in studies done in Idaho, western Wyoming and Montana (Hansen et al., 1989; Mueggler et al., 1980). For each community type listed in Table AP6.1 the PLANTS database acronym for the species name is given; followed by the common name and overstory/understory symbols which describe the physiognomic class of the overstory/understory species. (For example CF/S and CF/G mean coniferous forest/shrub and coniferous forest/grass respectively).

Sources:

Alexander, R.R. 1985. **Major Habitat Types, Community Types and Plant Communities in the Rocky Mountains.** GTR-RM-123 Fort Collins, CO

Collins, E.I. 1984. Preliminary Classification of Wyoming Plant Communities. Wyoming Natural Heritage Database Cheyenne, WY

Collins, E.I. 1984. A bibliography of Wyoming Plant Community Descriptions. Prairie Naturalist 16(1):25-38

Cooper, D.J. 1990. **Ecology of Wetlands in Big Meadows, Rocky Mountain National Park.** USDI FWS Biological Report 90(15).

DeVelice, R.L., Ludwig, J.A., Moir, W.H. and F. Ronco, Jr. 1986. **A classification of Forest Habitat Types of Northern New Mexico and Southern Colorado.** GTR- RM-131. Fort Collins, CO

Hansen, P., Pfister, R., Joy, J., Svboda, D., Boggs, K. Myers, L., Chadde, S. and J. Pierce. 1989. **Classification and Management of Riparian Sites in Southwestern Montana (SW MT)** Draft Version 2. Montana Riparian Assn School of Forestry U. of MT. Missoula

Hansen, P., Boggs, K., Pfister, R. and J. Joy. 1990. **Classification and Management of Riparian and Wetland Sites in Central and Eastern Montana. (CN MT)** Draft Version 2. Montana Riparian Assn, Montana Conservation Expt. Station, School of Forestry and U. of Mont. Missoula

Integrated Riparian Evaluation Guide (R-4) 1992

Johnston, B.C. 1987. **Plant Associations of Region 2.** R2-ECOL-87-2 Denver

Jones,G. 1992. **A Preliminary Classification of Riparian Vegetation Types of the Medicine Bow Range and the Sierra Madre.** Laramie

Kittel, G.M. and N.D. Lederer. 1993. **A Preliminary Classification of the Riparian Vegetation of the Yampa and San Miguel/Dolores River Basins.** Final Report to the Colorado Department of Health and EPA by the Nature Conservancy. Boulder, CO

Kittel, G.W., Rondeau, R., Lederer, N. and D. Randolph. 1994. **A Classification of the Riparian Vegetation of the White and Colorado River Basins, Colorado.** Final Report for the Colorado Department of Naturla Resources and the EPA by the Colorado Natural Heritage Program. Boulder, CO

Mueggler, W.F. and Stewart, W.L. 1980. **Grassland and Shrubland Habitat Types of Western Montana.** USDA Forest Service GTR INT-66 Ogden, Utah

Wyoming Natural Diversity Database. 1992. Wyoming Plant Community Classification. WYNDD Laramie, WY

Acronym Symbols are from: **PLANTS - Plant List of Accepted Nomenclature, Taxonomy and Symbols Alphabetical Listing Report.** 1992. USDA Soil Conservation Service Beltsville, MD

Common names are from: **Plants of Wyoming - Alphabetical Listing.** 1993. U.S. Soil Conservation Service Beltsville, MD

TABLE AP6.1 WORKING LIST OF COMMUNITY TYPES - MEDICINE BOW NATIONAL FOREST

FOREST

ACRONYM	COMMON NAME	TYPE
CONIFEROUS FOREST (CF) Upland		
	SPRUCE-FIR FOREST	
Abla-Pien/Vace	spruce-fir/dwarf huckleberry	CF/S
Abla-Pien/Vasc	spruce-fir/grouse whortleberry	CF/S
Abla-Pien/Cage2	spruce-fir/elk sedge	CF/G
Abla-Pien/Caro5	spruce-fir/Ross sedge	CF/G
Abla-Pien/Caru3	spruce-fir/rock sedge	CF/G
Abla-Pien/moss	spruce-fir/moss	
Abla/Juco6	fir/common juniper	CF/S
Abla/Mare11	fir/Oregon grape	CF/S
*Abla/Vasc	fir/grouse whortleberry	CF/S
Abla/Acru2	fir/red baneberry	CF/F
Abla/Arco9	fir/heartleaf arnica	CF/F
Abla/Erex4	fir/fleabane	CF/F
Abla/Caru	fir/pinegrass	CF/G
*Abla/Cage2	fir/elk sedge	CF/G
Abla/Caro5	fir/Ross sedge	CF/G
*Abla/Moss	fir/moss	CF/G
Pien/Juco6	spruce/common juniper	CF/S
Pien/Vasc	spruce/grouse whortleberry	CF/S
Pien/Arco9	spruce/heartleaf arnica	CF/F
	LODGEPOLE PINE FOREST	
*Pico/Juco6	lodgepole pine/common juniper	CF/S
Pico/Aruv	lodgepole pine/kinnikinnik	CF/S
Pico/Putr2	lodgepole pine/antelope bitterbrush	CF/S
*Pico/Shca	lodgepole pine/russett buffaloberry	CF/S
*Pico/Vasc	lodgepole pine/grouse whortleberry	CF/S
Pico/Arco9	lodgepole pine/heartleaf arnica	CF/F
Pico/Geca3	lodgepole pine/Fremont geranium	CF/F
Pico/Pamy	loegepole pine/paxistima	CF/F
Pico/Feid	lodgepole pine/Idaho fescue	CF/G
Pico/Caru	lodgepole pine/pinegrass	CF/G
*Pico/Cage2	lodgepole pine/elk sedge	CF/G
*Pico/Caro5	lodgepole pine/Ross sedge	CF/G
Pico/lichen	lodgepole pine/lichen	CF/G

LIMBER PINE FOREST

*Pifl2/Juco6	limber pine/common juniper	CF/S
Pifl2/Aruv	limber pine/kinnikinnik	CF/S
Pifl2/Capu	limber pine/purple reedgrass	CF/G
*Pifl2/Leki2	limber pine/king spikefescue	CF/G
Pifl2/Pssps	limber pine/bluebunch wheatgrass	CF/G

PONDEROSA PINE FOREST

Pipo/Jusc2	ponderosa pine/Rocky Mtn. juniper	CF/S
Pipo/Juco6	ponderosa pine-common juniper	CF/S
*Pipo/Aruv	ponderosa pine/kinnikinnik	CF/S
Pipo/Cemo	ponderosa pine-mountain mahogany	CF/S
Pipo/Phmo4	ponderosa pine/mountain ninebark	CF/S
Pipo/Putr2	ponderosa pine/bitterbrush	CF/S
Pipo/Artr2-Feid	ponderosa pine/big sagebrush-Idaho fescue	CF/G
Pipo/Feid	ponderosa pine/Idaho fescue	CF/G
Pipo/Leki2	ponderosa pine/king spikefescue	CF/G
*Pipo/Cage2	ponderosa pine/elk sedge	CF/G
*Pipo/Caro5	ponderosa pine/Ross sedge	CF/G
Pipo/Cain9	ponderosa pine/sun sedge	CF/G
Pipo-Psme/Phmo4	ponderosa pine-Dougas-fir/mountain ninebark	CF/G
Pipo-Psme/Mumo	ponderosa pine-Douglas-fir/mountain muhly	CF/G

DOUGLAS FIR FOREST

Psme/Aruv-Juco6	Douglas-fir/kinnikinnik-common juniper	CF/S
Psme/Cemo2	Douglas-fir/mountain mahogany	CF/S
Psme/Jaam4	Douglas-fir/cliff jamesia	CF/S
Psme/Mare11	Douglas-fir/Oregon-grape	CF/S
Psme/Phmo4	Douglas-fir/mountain ninebark	CF/S
Psme/Caru	Douglas-fir/pinegrass	CF/G
Psme/Feid	Douglas-fir/Idaho fescue	CF/G
Psme/Cage2	Douglas-fir/elk sedge	CF/G
Psme/Caro5	Douglas-fir/Ross sedge	CF/G

CONIFEROUS FOREST (CF) Riparian

SPRUCE-FIR FOREST

Abla-Pien/RIBES	spruce-fir/currant	CF/S
Abla-Pien/Sagl	spruce-fir/grayleaf willow	CF/S
Abla-Pien/Arla8	spruce-fir/broadleaf arnica	CF/F
Abla-Pien/Libo3	spruce-fir/twinflower	CF/F
Abla-Pien/Meci3	spruce-fir/mountain bluebells	CF/F

Abla-Pien/Setr	spruce-fir/arrowleaf groundsel	CF/F
Abla-Pien/Caca4	spruce-fir/bluejoint reedgrass	CF/G
Abla-Pien/moss	spruce-fir/moss	CF/G
Abla/Arla8	fir/broadleaf arnica	CF/F
Abla/Gatr3	fir/sweet-scented bedstraw	CF/F
Abla/Libo3	fir/twinflower	CF/F
Abla/Pera	fir/sickletop lousewort	CF/F
Abla/Caca4	fir/bluejoint reedgrass	CF/G
Abla/moss	fir/moss	CF/G
Pien/Cale4	Engelmann spruce/elkslip marshmarigold	CF/F
Pien/Gatr3	Engelmann spruce/sweet-scented bedstraw	CF/F
Pien/Libo3	Engelmann spruce/twinflower	CF/F
Pien/Mast4	Engelmann spruce/wild lily-of-the-valley	CF/F
Pien/Cadi6	Engelmann spruce/softleaved sedge	CF/G
Pien/Eqar	Engelmann spruce/field horsetail	CF/G
Pien/moss	Engelmann spruce/moss	CF/G
Pien-Pipu/Gatr3	Engelmann spruce-blue spruce/ sweet-scented bedstraw	CF/F

LODGEPOLE PINE FOREST

Pico/Libo3	lodgepole pine/twinflower	CF/F
Pico/Casc12	lodgepole pine/Holm's Rocky Mountain sedge	CF/G

BLUE SPRUCE FOREST

Pipu/Alin2	blue spruce/thinleaf alder	CF/S
Pipu/Amal2-Cose16	blue spruce/Saskatoon serviceberry-red-osier dogwood	CF/S
Pipu/Cose16	blue spruce/red-osier dogwood	CF/S
Pipu/Arco9	blue spruce/heartleaf arnica	CF/F
Pipu/Eqar	blue spruce/field horsetail	CF/G
Pipu/Popr	blue spruce/Kentucky bluegrass	CF/G
Pipu-Pien1/Eqar	blue spruce-Engelmann spruce/field horsetail	CF/G

PONDEROSA PINE FOREST

Pipo/Cose16	ponderosa pine/red-osier dogwood	CF/S
Pipo/Prvi	ponderosa pine/common chokecherry	CF/S
Pipo/Popr	ponderosa pine/Kentucky bluegrass	CF/G

DOUGLASFIR FOREST

Psme/Cose16	Douglasfir/red-osier dogwood	CF/S

DECIDUOUS FOREST (DF) (Upland)

ASPEN FOREST

Potr5/Juco	aspen/common juniper	DF/S
Potr5/Amal2-Prvi	aspen/S.serviceberry-common chokecherry	DF/S
Potr5/Artr2	aspen/big sagebrush	DF/S
Potr5/Ceve	aspen/snowbrush ceanothus	DF/S
Potr5/Syor2	aspen/whortleleaf snowberry	DF/S
Potr5/Lala3	aspen/aspen peavine	DF/F
Potr5/Luar	aspen/silvery lupine	DF/F
Potr5/Raal	aspen/plantainleaf buttercup	DF/F
Potr5/Wyam	aspen/mulesears wyethia	DF/F
Potr5/Caru3	aspen/rock sedge	DF/G
*Potr5/Cage2	aspen/elk sedge	DF/G

ASPEN-SUBALPINE FIR FOREST

Potr5-Abla/Mare11	aspen-subalpine fir/oregon grape	DF/S
Potr5-Abla/Prvi	aspen-subalpine fir/common chokecherry	DF/S
Potr5-Abla/Shca	aspen-subalpine fir/russett buffaloberry	DF/S
Potr5-Abla/Syor2	aspen-subalpine fir/whortleleaf snowberry	DF/S
Potr5-Abla/Arco9	aspen-subalpine fir/heartleaf arnica	DF/F
Potr5-Abla/Lifi	aspen-subalpine fir/fernleaf ligusticum	DF/F
Potr5-Abla/Pera	aspen-subalpine fir/sickletop lousewort	DF/F

ASPEN-LODGEPOLE PINE FOREST

Potr5-Pico/Caru	aspen-lodgepole pine/pinegrass	DF/G

ASPEN-DOUGLAS-FIR FOREST

Potr5-Psme/Amal2	aspen-Douglas-fir/Saskatoon serviceberry	DF/S
Potr5-Psme/Caru	aspen-Douglas-fir/pinegrass	DF/G

DECIDUOUS FOREST (DF) (Riparian)

BOXELDER FOREST

Acne2/Cose16	boxelder/red-osier dogwood	DF/S
Acne2/Prvi	boxelder/common chokecherry	DF/S

NARROWLEAF COTTONWOOD FOREST

Poan3/Alin2-Cose16	narrowleaf cottonwood/S. serviceberry-red-osier dogwood	DF/S
Poan3/Beoc2	narrowleaf cottonwood/water birch	DF/S
Poan3/Cose16	narrowleaf cottonwood/red-osier dogwood	DF/S
Poan3/Rhtr	narrowleaf cottonwood/skunkbrush sumac	DF/S
Poan3/Rowo	narrowleaf cottonwood/Wood's rose	DF/S
Poan3/Saex-Beoc2	narrowleaf cottonwood/coyote willow-water birch	DF/S
Poan/Popr	narrowleaf cottonwood/Kentucky bluegrass	DF/G

BALSAM POPLAR FOREST

Poba2/Cose16	balsam poplar/red-osier dogwood	DF/S

PLAINS COTTONWOOD FOREST

Podem/Syoc-Saex	plains cottonwood/western snowberry-coyote willow	DF/S

ASPEN FOREST

Potr5/Beoc2	aspen/water birch	DF/S
Potr5/Cose16	aspen/red-osier dogwood	DF/S
Potr5/Mare11	aspen/Oregon grape	DF/S
Potr5/Rowo	aspen/Wood's rose	DF/S
Potr5/Sage2	aspen/Geyer willow	DF/S
Potr5/Gevi2	aspen/sticky geranium	DF/F
Potr5/Hesp6	aspen/cow parsnip	DF/F
Potr5/Lipo	aspen/Porter's ligusticum	DF/F
Potr5/Osoc	aspen/western sweetroot	DF/F
Potr5/Ptaq	aspen/bracken fern	DF/F
*Potr5/Thfe	aspen/Fendler meadowrue	DF/F
Potr5/Veca2	aspen/false hellebore	DF/F
Potr5/Popr	aspen/Kentucky bluegrass	DF/G
*Potr5/Caru	aspen/pinegrass	DF/G
Potr5/Eqar	aspen/field horsetail	DF/G

ASPEN-SUBALPINE FIR FOREST

Potr5-Abla/Thfe	aspen-subalpine fir/Fendler meadowrue	DF/F

WOODLAND

CONIFEROUS WOODLAND (CW) (Upland)

ROCKY MOUNTAIN JUNIPER WOODLAND

Jusc2/Artr2	Rocky Mountain juniper/big sagebrush	CW/S
Jusc2/Cemo2	Rocky Mountain juniper/mountain mahogany	CW/S
Jusc2/Putr2	Rocky Mountain juniper/antelope bitterbrush	CW/S
Jusc2-Pssps	Rocky Mountain juniper/bluebunch wheatgrass	CW/G

DECIDUOUS WOODLAND (DW) (Upland)

GAMBEL OAK WOODLAND

Quga/Amal2	Gambel oak/Saskatoon serviceberry	DW/S
Quga-Prvi/Pamy	Gambel oak-common chokecherry/ myrtle paxistima	DW/S
Quga/Syor2	Gambel oak/whortleleaf snowberry	DW/S

SHRUBLAND

SHRUBLAND NON-WILLOW (SHNW) (Upland)

SERVICEBERRY SHRUBLAND

Amal2/Putr2-Pssps	S.serviceberry/antelope bitterbrush-bluebunch wheatgrass	SHNW/S
Amal2/Syor2-Artr2	S.serviceberry/whortleleaf snowberry-big sagebrush	SHNW/S
Amal2-Prvi/Viam	S.serviceberry-common chokecherry/ American vetch	SHNW/F
Amal2/Cage2	Saskatoon Serviceberry/elk sedge	SHNW/G

SAGEBRUSH SHRUBLAND

Artr2-Putr2/Ellal	big sagebrush-antelope bitterbrush/ thickspike wheatgrass	SHNW/G
Artr2-Putr2/Pssm	big sagebrush-antelope bitterbrush/ western wheatgrass	SHNW/G
Artr2/Feid	big sagebrush/Idaho fescue	SHNW/G
Artr2/Leki2	big sagebrush/king spikefescue	SHNW/G
Artr2/Pssps	big sagebrush/bluebunch wheatgrass	SHNW/G
Artr2/Pssm	big sagebrush/western wheatgrass	SHNW/G
Artr2/Orhy	big sagebrush/indian ricegrass	SHNW/G
Artr2/Stco4	big sagebrush/needleandthread	SHNW/G
Artr2/Stne3	big sagebrush/Columbia needlegrass	SHNW/G
Artr4/Feid	threetip sagebrush/Idaho fescue	SHNW/G

MOUNTAIN MAHOGANY SHRUBLAND

Cemo2-Rhtr/Ange	mountain mahogany-skunkbrush sumac/ big bluestem	SHNW/G
Cemo2/Ellal	mountain mahogany/thickspike wheatgrass	SHNW/G
Cemo2/Feid	mountain mahogany/Idaho fescue	SHNW/G
Cemo2/Pssps	mountain mahogany/bluebunch wheatgrass	SHNW/G
Cemo2/Stco4	mountain mahogany/needleandtrhead	SHNW/G

OCEAN SPRAY SHRUBLAND

Hodu/Rice	ocean-spray/wax currant	SHNW/S

ANTELOPE BITTERBRUSH SHRUBLAND

Putr2-Artr2/Feid	antelope bitterbrush-big sagebrush/ Idaho fescue	SHNW/G
Putr2-Artr2/Pssp	antelope bitterbrush-big sagebrush/ western wheatgrass	SHNW/G
Putr2/Mumo	antelope bitterbrush/mountain muhley	SHNW/G
Putr2/Stco4	antelope bitterbrush/needleandthread	SHNW/G

SKUNKBRUSH SUMAC SHRUBLAND

Rhtr/Feid	skunkbrush sumac/Idaho fescue	SHNW/G

WESTERN SNOWBERRY SHRUBLAND

Syoc/Pssm	western snowberry/western wheatgrass	SHNW/G

SHRUBLAND NON-WILLOW (SHNW) (Riparian)

MOUNTAIN MAPLE SHRUBLAND

Acgl/Cose16	Mountain maple/red-osier dogwood	SHNW/S

THINLEAF ALDER SHRUBLAND

Alin2-Beoc2/SALIX	thinleaf alder-water birch/willow	SHNW/S
Alin2-Beoc2/Caaq	thinleaf alder-water birch/water sedge	SHNW/G
Alin2/Eqar	thinleaf alder/field horsetail	SHNW/G

SILVER SAGEBRUSH SHRUBLAND

Arca13/Feid	silver sagebrush/Idaho fescue	SHNW/G
Arca13/Pssm	silver sagebrush/western wehatgrass	SHNW/G

BIG SAGEBRUSH SHRUBLAND

Artr2/Leci4	big sagebrush/basin wildrye	SHNW/G

WATER BIRCH SHRUBLAND

Beoc/Cose16	water birch/red-osier dogwood	SHNW/S

RED-OSIER DOGWOOD SHRUBLAND

Cose16/Gatr3	red-osier dogwood/sweet-scented bedstraw	SHNW/F
Cose16/Hesp	red-osier dogwood/cow parsnip	SHNW/F

CHOKECHERRY SHRUBLAND

Prvi-Syoc/Pssm	chokecherry-western snowberry/ western wheatgrass	SHNW/G
Prvi/Rowo	chokecherry/Wood's rose	SHNW/S

SHRUBBY CINQUEFOIL SHRUBLAND

Pefl15/Feid	shrubby cinquefoil/Idaho fescue	SHNW/G
Pefl15/Dece	shrubby cinquefoil/tufted hairgrass	SHNW/G
Pefl15/Popr	shrubby cinquefoil/Kentucky bluegrass	SHNW/G

SHRUBLAND WILLOW (SHW) (Riparian)

WILLOW SHRUBLAND

Tall Willow

Sabe2	Bebb willow	SHW
Sabo2-SALIX/Caca4	Booth willow-willow/bluejoint reedgrass	SHW/G
Sabo2-SALIX/Caro6	Booth willow-willow/beaked sedge	SHW/G
Sadr/Caca4	Drummond willow/bluejoint reedgrass	SHW/G
Saex-SALIX/POA	coyote willow-willow/Kentucky bluegrass	SHW/G
Saex-SALIX/Caca4	coyote willow-willow/bluejoint reedgrass-	

-Eqar	field horsetail	SHW/G
Saex/Rowo	coyote willow/Wood's rose	SHW/S
Saex/Popr	coyote willow/Kentucky bluegrass	SHW/G
Sage2-SALIX/Caca4	Geyer willow-willow/bluejoint reedgrass	SHW/G
Sage2-SALIX/Caro6	Geyer willow-willow/beaked sedge	SHW/G
Sage2/Caca4	Geyer willow/bluejoint reedgrass	SHW/G
Sage2/Dece	Geyer willow/tufted hairgrass	SHW/G
Sage2/Popa2	Geyer willow/fowl bluegrass	SHW/G
Sage2/Popr	Geyer willow/Kentucky bluegrass	SHW/G
Sage2/Caaq	Geyer willow/water sedge	SHW/G
Sage2/Caro6	Geyer willow/beaked sedge	SHW/G
Sala	Pacific willow	SHW
Salu/Caca4	yellow willow/bluejoint reedgrass	SHW/G
Salu/Popr	yellow willow/Kentucky bluegrass	SHW/G
Salu/Caro6	yellow willow/beaked sedge	SHW/G
Salu/Eqar	yellow willow/field horsetail	SHW/G
Sapl2/Cale4	planeleaf willow/elkslip marigold	SHW/F
Sapl2/Caca4	planeleaf willow/bluejoint reedgrass	SHW/G
Sapl2/Dece	planeleaf willow/tufted hairgrass	SHW/G
Sapl2/Caaq	planeleaf willow/water sedge	SHW/G
Sapl2/Casc12	planeleaf willow/Holm's Rocky mountain sedge	SHW/G
	Short Willow	
Saar4/Geror	arctic willow/golden avens	SHW/F
Saca4-SALIX/Caaq	sageleaf willow-willow/water sedge	SHW/G
Sagl-SALIX/CAREX	grayleaf willow-willow/sedge	SHW/G
Sagl-Sabr/Dece	grayleaf willow-barrenground willow/ tufted hairgrass	SHW/G
Sagl/Geror	grayleaf willow/golden avens	SHW/F
Sawo/Frvi	wolf willow/Virginia strawberry	SHW/F
Sawo/Dece	wolf willow/tufted hairgrass	SHW/G
Sawo/Caca4	wolf willow/bluejoint reedgrass	SHW/G
Sawo/Caaq	wolf willow/water sedge	SHW/G
Sawo/Caro6	wolf willow/beaked sedge	SHW/G

FORBLAND

FORBLAND (FO) (Upland)

MOUNTAIN DRYAD FORBLAND

Droc/Caru3	Mtn. dryad/rock sedge	FP/G
Droc/Caru	mountain dryad/pinegrass	FO/G

GOLDEN AVENS FORBLAND

Geror-TRIFO/Dece	golden avens-clover/tufted hairgrass	FO/G
Geror/Trda2	golden avens/whiproot clover	FO/FO
Geror/Pobi6	golden avens/American bistort	FO/FO

SIBBALDIA FORBLAND

Sipr/Caeb	sibbaldia/ebony sedge	FO/G
Sipr/Capy3	sibbaldia/pyrenean sedge	FO/G

FORBLAND (FO) (Riparian)

BROOKCRESS FORBLAND

Caco6/Cale4	brook-cress/elkslip marshmarigold	FO/FO

MARSHMARIGOLD FORBLAND

Cale4	elkslip marigold	FO/FO
Cale4/Serh	elkslip marshmarigold/rose-crown	FO/FO
Ciar4	cirsium arvense	FO

MISCELLANEOUS FORBLANDS

Cisc3/Aqco	alpine thistle/Colorado columbine	FO/FO
Lipo/Lupa8	Porter ligusticum/lodgepole lupine	FO
Mear4	field mint	FO
Meci3	mountain bluebells	FO
Meci3/Dece	mountain bluebells/tufted hairgrass	FO/G
Migu	yellow monkeyflower	FO
Rona2	watercress	FO
Prpa2/Dece	Parry primrose/tufted hairgrass	FO/G
Raaq	aquatic buttercup	FO
Saod2/Dece	brook saxifrage/tufted hairgrass	FO/G
Setr/Lifi	arrowleaf groundsel/fernleaf ligusticum	FO/FO
Trla2-Lifi/Erpe3	globeflower-fernleaf ligusticum/ peregrine fleabane	FO/FO
Trpa5/Dece	Parry clover/tufted hairgrass	FO/G
Tyla	common cattail	FO

GRASSLAND

GRASSLAND (GRS) (Upland)

TUFTED HAIRGRASS GRASSLAND

Dece/Geror	tufted hairgrass/golden avens	GRS/FO

DANTHONIA GRASSLAND

Dapa2/Feid	Parry danthonia/Idaho fescue	GRS/GRS
Dain/Podi2	timber oatgrass/varileaf cinquefoil	GRS/FO
Dain	timber danthonia	GRS

IDAHO FESCUE GRASSLAND

Feid/Dece	Idaho fescue/tufted hairgrass	GRS/GRS

MOUNTAIN MUHLEY GRASSLAND

Mumo/Ellal	mountain muhley/thickspike wheatgrass	GRS/GRS

STIPA GRASSLAND

Stco4/Caeb	needleandthread/ebony sedge	GRS/GRM
Stco4/Bogr	needleandthread/blue grama	GRS/GRS

WESTERN WHEATGRASS GRASSLAND

Pssm/Pofe	western wheatgrass/muttongrass	GRS/GRS
Pssm/Stco4	western wheatgrass/needlegrass	GRS/GRS

BLUEBUNCH WHEATGRASS GRASSLAND

Pssps/Pose	bluebunch wheatgrass/sandberg bluegrass	GRS/GRS

GRASSLAND (GRM) (Upland)

MISCELLANEOUS SEDGELANDS

Cadu6/Sede2	needleleaf sedge/selaginella	GRM/FO
Cafo3/Geror	wind sedge/golden avens	GRM/FO
Caru3/Komy	rock sedge/kobresia	GRM/GRM
Caru3/Trda2	rock sedge/whiproot clover	GRM/FO

KOBRESIA SEDGELANDS

Komy/Geror-Caru3	Kobresia/golden avens-rock sedge	GRS/FO
Komy/Trda2	Kobresia/whiproot clover	GRM/FO

GRASSLAND (GRS) (Riparian)

MISCELLANEOUS GRASSLANDS

Agsc5	ticklegrass	GRS
Agst2	carpet bentgrass	GRS
Alae	shortawn foxtail	GRS
Caaq3/Caaq	brookgrass/water sedge	GRS/GRM
Hobr2	meadow barley	GRS
Popa2	fowl bluegrass	GRS
Popr	Kentucky bluegrass	GRS

TUFTED HAIRGRASS GRASSLANDS

Dece	tufted hairgrass	GRS
Dece/CAREX	tufted hairgrass/sedge	GRS/GRM
Dece/Cale4	tufted hairgrass/marsh marigold	GRS/FO

BLUEJOINT REEDGRASS GRASSLANDS

Caca4	bluejoint reedgrass	GRS
Caca4-Casc12/Meci3	bluejoint reedgrass-Holm's Rocky Mountain sedge/mtn. bluebells	GRS/FO

MANNAGRASS GRASSLANDS

GLYCE	mannagrass	GRS
Glbo	northern mannagrass	GRS

GRASSLAND (GRS) (Riparian)

MISCELLANEOUS SEDGELANDS

Caaq	water sedge	GRM
Caaq/Caro6	water sedge/beaked sedge	GRM/GRM
Caaq/Pegr2	water sedge/elephanthead lousewort	GR/FO
Caaq/Caho5	water sedge/Hood sedge	GRM/GRM
Caca12/Povi6	hairlike sedge/American bistort	GRM/FO
Caro6	beaked sedge	GRM
Cami7	smallwing sedge	GRM
Cami7/Dece	smallwing sedge/tufted hairgrass	GRM/GRS
Cane2	Nebraska sedge	GRM
Cane2/Caaq3-Juba	Nebraska sedge/brookgrass-Baltic rush	GRM
Cane2/Dece	Nebraska sedge/tufted hairgrass	GRM/GRS
Casi2/Dece	short-beaked sedge/tufted hairgrass	GRM/GRS

Casc12	Holm's Rocky Mountain sedge	GRM
Casc12/Dece	Holm's Rocky Mountain sedge/ tufted hairgrass	GRM/GRS
Casc12/Cale4	Holm's Rocky Mountain sedge/ elkslip marshmarigold	GRM/FO

SPIKERUSHES

Elpa3	creeping spikerush	GRM
Elpa3/CAREX	creeping spikerush/sedge	GRM/GRM

RUSHLANDS, BULRUSHES, HORSETAILS

Juba	Baltic rush	GRM
Juba/CAREX	Baltic rush/sedge	GRM/GRM
Judr/CAREX	Drummond rush/sedge	GRM/GRM
Juen	swordleaf rush	GRM
Scmi2	panicled bulrush	GRM
Eqar	field horsetail	GRM

APPENDIX 7

LICHEN SPECIES BIOLOGICAL DIVERSITY

Lichens are slow growing perennial organisms resulting from a symbiotic association of a fungus and one or more algal or cyanobacterial species. Lichens have been recognized for about 2000 years. The term lichen is derived from a Greek word meaning tree moss, and was first used by Theophrastus who described bark lichens from olive trees three centuries B.C. (Richardson, 1974; Hale and Cole, 1988). Interest in lichens and their curative powers continued through the Middle Ages with the herbalists (L'Obel, 1576; Gunther, R.T). In 1741, all known lichens were illustrated in a publication from Oxford University (Richardson, 1974).

There is good general information on the distribution of common species, lichen succession and specificity of habitat Ecological information was obtained primarily from Wetmore (1967); Hale (1969); Hale (1974); Richardson, D.H.S., 1974; Seaward (1977); Dale (1982); Galun (1988); Vitt et al. (1988); Pike (1988); Nash and Wirth (1988); Eversman (1990); Eversman et al (1987); Knops et al. (1991); Rosentreter (1993); St. Clair and Johansen (1993).

Several major groups of fungi associate primarily with green algae (Chloroccae) or cyanobacteria bacteria (Cyanophyceae) to form lichens. In the cyanobacteria group, the genera *Nostoc* and *Anabaena* have the ability to fix nitrogen. Thus the lichens in which they are found may play a special ecological role. Although the partnership can be very specific between the fungus and alga and/or cyanobacterium, sometimes more than one algal or bacterial species is associated with a particular fungal partner or vice versa, making taxonomy, identification and ecological/physiological classification difficult (Tschermak-Woess, 1988).

Lichens can be grouped according to biogeographical affinity. These have been used to relate lichen distibution to vascular plant evolution, dispersal and ecology and to plate tectonics. Many lichen species are worldwide in distribution, but are found in particular climatic zones such as the arctic-alpine tundra, the boreal forest, temperate forest, tropics, desert or grasslands. Wetmore (1968) discusses the affinities of the Black Hills lichen flora with floristic distributions of vascular plants belonging to the Boreal, Neo-Tropical (SE U.S); or Madro-Tertiary (SW U.S.) floras. The Neo-Tropical and Madro-Tertiary groups of vascular plants are believed to have evolved to their present form and distribution during the Tertiary Period. Events of the last 20,000 years in North America have framed their present distribution. This large time-frame includes both pre-settlement times and the period of accelerated change in post-settlement Western North America. The

distribution of lichens, along with the vascular plants, have been affected by these forces and changes.

Factors which affect the diversity of lichens on a large geographic scale include elevation, geologic substrate, sharpness of relief, climatic range and vegetation types. Local factors include substrate, local climate, humidity, surface moisture, and species interactions. Wetmore (1967) found few distributional differences for lichens in the Black Hills due to elevation. The greatest diversity was in valleys and the least in the prairies or open ponderosa pine systems. Wetmore (1967) attributes this to the fact that rugged topography and deep valleys create more complex and moister microclimates favorable to lichens in the valleys.

Lichens of the Medicine Bow National Forest

Nomenclature for lichens changes more rapidly than for vascular plants. For this reason, because lichen identification to species has some uncertainty, and because more work needs to be done on the lichen flora of the Medicine Bow National Forest, there may be some differences of opinion regarding the lists presented here. For Tables AP7.1 and AP7.2, all lichen names were updated according to Egen (1991) from previously documented and identified specimens. Names for lichens from the 1993 Lichen Survey (Table AP7.3) are tentative, pending verification by lichen experts.

Table AP7.1 summarizes information about lichens on the Medicine Bow National Forest and areas in Colorado, Wyoming and South Dakota. Table AP7.1 presents:

1. life form (crustose, fruticose or foliose)

2. the substrate recorded for documented species

3. biogeographical affinity

4. Regional distribution - co-occurrence of lichens on the Medicine Bow National Forest with lichen species in the Flat Tops area of the Routt National Forest (CO) (Hale,1982); Yellowstone National Park (WY) (Eversman, 1990); the Wind River Mountains (WY) (St. Clair and Newberry, 1993); Black Hills (SD) (Wetmore, 1967) and Fraser Experimental Forest, Colorado (Popovich et al, 1993).

5. Local distribution

Characteristics of documented lichen species within the Medicine Bow National Forest for the Sherman Mountains and the Medicine Bow Mountains are presented in Table AP7.2. No work has

been done on lichens in the Laramie Mountains and only a few specimens were found in the Rocky Mountain Herbarium form the Sierra Madre.

Of the 95 species of lichens documented in or near the Medicine Bow National Forest, there are 37 crustose species, 38 foliose species and 19 fruticose species (Table 1). Sixty-six species are known from the Medicine Bow Mountains, 58 from the Sherman Hills and 18 species from both. Thirty-nine species occur primarily on rock, 20 on bark, 17 on decaying organicmatter, 15 on soil, 2 on dry wood (lignin) and 2 are vagrant (unattached on soil).

Geographic affinities for 51 of the 95 species was derived from those which are also known from the Black Hills. Over half are Arctic-Boreal species (characteristic of Arctic or Alpine tundra), and about 20% are Pan-Boreal (found throughout the boreal forest worldwide).

The surprisingly low commonality of species among the four areas with documented lists, within 300 miles of the Medicine Bow National Forest boundary, reflects not only true differences in biogeographical distribution, habitat, elevation, and climate, but also completeness of collection and documentation. Only six species are reported for all areas (*Cladonia chlorophea, Cladonia pyxidata, Peltigera canina, Peltigera venosa, Rhizocarpon geographicum, Umbilicaria hyperborea*). The information on lichen species diversity for the Medicine Bow National Forest is rudimentary, but it is a start at describing species richness and some aspects of lichen community ecology.

Ten species are associated with nitrogen-fixing cyanobacteria. Of this group, seven grow on soil (*Peltigera* spp.), one species grows on rock (*Collema polycarpon*) and two on decaying material (*Pannaria pezizoides, Stereocaulon tomentosum)*). The *Peltigera* and *Pannaria species* are characteristically found in coniferous forests.

The importance of lichens in biogeochemical cycling is being investigated (Brown and Brown, 1991; Knops et al, 1991). Half of the annual total nitrogen input into tundra and taiga systems of Alaska is via lichens and an estimated 3.5 kg/hectare/year is added to Douglas-fir forests via lichens (Galun, 1988; Knops et al, 1991). The role of lichens in the nutritional status of dry heathland and woodland ecosystems of the Arctic and Subarctic, tundra, and old growth Douglas-fir ecosystems of the Pacific Northwest has been documented (Knops et al, 1991). Lichens increase biochemical diversity in an ecosystem, they supplement other structural attributes of forests and they provide habitat for a wide array of microfloral and microfaunal species (Seaward, 1977).

In the lodgepole pine and spruce-fir forests of the Medicine Bow National Forest there are limited sources of nitrogen-fixation. Shrubs such as buffaloberry (*Shepherdia*), alder (*Alnus*) and antelope bitterbrush (*Purshia*) and forbs such as lupine, have nitrogen-fixing bacteria in root nodules. Lichens are likely another source of biological nitrogen fixation. This nitrogen becomes available to vascular plants through leaching and through decomposition (Kershaw, 1985). *Peltigera* is the the major genus of nitrogen-fixing lichens in the coniferous forests of the Medicine Bow.

Increased interest in lichens as biomonitors of air pollution and as indicators of other forest conditions has stimulated research in the past decade and a half. Lichens accumulate various air pollutants, particularly sulfur compounds and heavy metals (mercury, copper, nickel, zinc, cadmium and others) (Puckett, 1988; Huckaby, 1993). Three genera of lichens are now used to monitor effects of air pollution in wilderness areas of National Forests in Region 2 (Musselmann, 1994). In the summer of 1993, a part of a Regional air pollution monitoring study *Usnea*, *Bryoria* and *Xanthoparmelia* samples were collected from Savage Run Wilderness, the GLEES area and a site near Sand Lake for chemical tests on accumulation of sulfur and nitrogen compounds from air pollution. In January, 1995 the nearby Mount Zirkel Wilderness in Colorado had the highest measured snowpack sulfate concentrations ever measured west of the Mississippi (Routt/Medbow National Forest News Release, 1995).

Lichens may assist the monitoring efforts for sulfur and other pollutants. Baseline measurements have been made in lichens occurring the Bridger Teton Wilderness to monitor accumulation of nickel, copper, zinc, lead, mangenese, iron and cobalt. Sensitivity to fluorides, ozone and sulfur dioxide was also measured. Increases in concentrations of most of the metals were found in this study compared to measurements made in 1985, although most of the concentrations were relatively low andthere did not appear to be any damage to the lichens (St. Clair and Newberry, 1993).

Most of the lichens they found to be sensitive to pollutants occur on the Medicine Bow National Forest also. These include: *Acarospora chlorophana, Bryoria fuscescens, Caloplaca holocarpa, Cladonia fimbriata, Letharia vulpina, Melanelia exasperatula, Parmeliopsis ambigua, Peltigera canina, Physica dubia, Rhizocarpon geographicum, Rhizoplaca melanopthalma, Usnea hirta,* and *Xanthoparmelia cumberlandia.*

Species of two epiphytic lichens (*Usnea* and *Bryoria*), grow on tree branches or trunks. *Usnea* sp. is green and *Bryoria* is black or dark brown. These are conspicuous species found in old coniferous forests. Epiphytic lichens accumulate both nutrients and pollutants by wet deposition, accumulation of fog, dew and mist, trapping of

particles (sedimentation or impaction) and direct uptake of gases such as SO_2 and NO_2. Because of these processes, epiphytic lichens can link forest canopy processes to other parts of forest ecosystem nutrient cycles (Knops et al, 1991). Both *Usnea* and *Bryoria* are used for monitoring air quality in Forest Service Region 2.

Lichen Survey

A survey collection of lichens was made in summer of 1994 to supplement other information on biological diversity in coniferous forest which had been harvested by clearcutting since 1950. (See Appendix 16). Dr. Judy von Ahlefelt, Forest Ecologist, and Sally Tinker, Biological Technician, collected lichens from 24 clearcut stands and adjacent uncut (sometimes tiehacked) stands. Voucher specimens are deposited at the Rocky Mountain Herbarium and the non-vascular cryptogam collection at Brigham Young University, Provo, Utah. The 24 sites are a subsample of sites (24 out of 54) used in the analysis of vascular plant biological diversity, succession, mycorrhizal infection and soil fertility in the clearcuts and uncut stands. Futher discussion of the larger project is in the Appendix on clearcuts. Lichens were collected from both clearcut sites and adjacent uncut forest. Four uncut stands used in the clearcut study were also sampled.

Mr. Tim Chumley, a botany major at the University of Wyoming, worked on preliminary identification of lichens found on soil, trees, or decaying organic matter. There was insufficient time to work on rock lichens in time for this report. Tentative identifications are to genus for most lichens. Samples of 36 common bark, soil and epiphytic lichens were sent to the M.L. Bean Life Science Museum cryptogammic herbarium at Brigham Young University for confirmation by Dr. Larry St. Clair. Further work is planned for the collection.

Lichens were collected from all substrates including bark and twigs of live and dead trees, decaying organic matter, soil and rocks. Lichens often associated with mosses on various substrates including bark and rocks, forming very complex communities.

The information from the survey is summarized in Table AP7.3 by ordination group based on understory species (see Appendix 16 on the biological diversity in clearcuts). *Cladonia cariosa* and *Peltigera rufescens* were found at most unharvested sites regardless of the cover type. Both are soil lichens. *P. rufescens* fixes nitrogen. Four species were found in very limited coourrences in sites clearcut since 1950. The other categories refer to lichens found in uncut stands adjacent to clearcut sites, grouped by cover type.

Lichens were found at all unharvested sites, both control sites for the clearcut survey, and unharvested adjacent stands. Approximately 40 species were differentiated. Epiphytic lichens (*Usnea lapponica* and *Bryoria fuscescens*) were found only in unharvested sites. Most lichens found on trunks or branches of trees, as well as most soil lichens, and all liches associated with decaying wood (mostly *Cladonia* spp. except for *C. cariosa)* were absent from sites clearcut since 1950. Genera include: *Bryoria, Buellia, Caloplaca, Candelariella, Lecanora, Lecidella, Melanelia, Parmeliopsis, Physcia, Parmeliopsis, Psoroma, Stereocaulon, Trapeliopsis and Usnea. Buellia, Candellariella, Melanelia and Physcia* respond negatively to snow depth (Gough, 1975). *Peltigera rufescens* and *Cladonia cariosa* were found in all ordination groups except Group 10. (Group 11 was not sampled for lichens due to time constraints).

Clearcut sites few lichen species. Lichens seen (except for rock lichens) were damaged or just beginning to develop. A few individuals or small colonies of *Cladonia* or *Peltigera* were develping in some of the stands harvested in the 1950's or 1960's if:

1. the canopy was tall (20 feet or more)
2. there were large individuals of subalpine fir or spruce in the stand and mosses were recolonizing the surface.

Few lichens characteristic of bark, twigs or decaying wood were found in the clearcut stands. Pieces of soil lichens in poor condition (mechanically damaged or dessicated) were observed in recently (1990-1993) clearcut stands. Clearcut sites are too dry and unprotected for any communities of decay to exist. Thus most *Cladonia* spp. and others associated with moss and molds were absent. One site, which had been burned, was also devoid of lichens, except for rocks which had not been burned over.

Some lichens form a cryptogammic crust on dry soils beneath lodgepole pine or limber pine. Cryptogammic soils beneath lodgepole pine were was noted in the southern part of the Medicine Bow Mountains on soils derived from the Sherman granite. Rollerchopping appears to be especially damaging to these soils and lichens, since the crust becomes broken and fine organic matter blows away. Rocks with lichens are buried or overturned, so these lichens do not persist either. On rollerchopped sites, lichens associated with rocks or dry soils persisted on rocky outcrops skirted by the rollerchopper.

Structural characteristics associated with the presence of lichens in lodgepole pine and spruce-fir forests are:

1. a tall closed canopy
2. protection from the wind by tree density and canopy
3. canopy interception of precipitation
4. dead and down logs which were partially buried and undergoing decay
5. dead and down logs which were not buried but shaded and moist enough to support decay
6. presence of mosses
7. presence of *Selaginella*
8. presence of subalpine fir

In unharvested and tiehacked stands several species were quite common. *Peltigera* sp. (nitrogen fixers) grew on soil. These often contained largest colonies several feet across in old forests. In tie-hacked or partially cut forests *Peltigera* colonies were smaller (5-6" across). Various species of *Cladonia* were most common on decaying wood.

Subalpine fir supports a the most diverse lichen flora. In contrast, lodgepole pine and Engelmann spruce had few lichen species on live trees. In the Sherman Mountains, both subalpine fir and limber pine supported lichen communities while ponderosa pine had few species (von Ahlefeldt, personal observation, 1993). Lichens on twigs and bark of subalpine fir and limber pine were found on trees of all sizes greater than about 4" DBH in uncut or tie-hacked stands. In the Medicine Bow Mountains, Engelmann spruce had few lichen species, although *Bryoria* and *Usnea* sometimes occurred thickly on spruce in sporadic sites in old forest especially near slope bottoms. Only one species of bark lichen, near the base of trees, was found on lodgepole pine. No lichens were found on lodgepole pine twigs, and *Usnea* and *Bryoria* rarely were found on lodgepole pine branches or trunks. *Cladonia* and other species which grow on fallen wood, readily colonize downed lodgepole pine, spruce and fir after decay begins.

The fewest lichens individuals and species were found in:

1. clearcuts
2. tie-hacked sites of all types
3. lodgepole pine sites at lower elevations (8000-8500 feet)
4. partially cut spruce-fir sites at higher elevations (9500-10,5000 feet)
5. very high elevation uncut spruce old growth (above 9800 feet)

In the Medicine Bow mountains the greatest lichen diversity was in uncut stands, or stands which had been thinned minimally by tie-hacking and not cut in the last 50 years (lodgepole pine, spruce, spruce-fir or mixed conifer) at elevations betweene 8500 and 9500 feet. Diversity was best especially on the west side of the Medicine Bow Mountains or north of Medicine Bow Peak (not including rock lichens).

Characteristics of stands which have a full complement of lichens are:

1. old, decaying logs
2. a thick layer of humus
3. protection from wind and sun by a well-developed and highly structured forest canopy
4. large, old trees.

Thus lichen biological diversity is positively associated with old forests, and also with increased diversity of fungal and microarthropod communities. This structural and biological diversity is lacking in young forest stands.

Livestock grazing, impact from logging equipment, and rollerchopping are all factors which disturb or destroy soil crust communities. The effects of livestock grazing differs from deer and elk. Grazing by livestock often causes trampling damage to *Peltigera* and breaks the microbiotic crust formed by other lichens, mosses and other microorganisms. The grazing-related damage to microbiotic crusts, which are important in increasing soil fertility because of increased organic matter and nitrogen, is especially critical in dry periods (St. Clair and Johansen, 1993). Deer and elk generally stay on game trails in forested areas rather than foraging widely. In grassland areas with high populations of vagrant lichens (Sherman Mountains -von Ahlefeldt, personal observation), livestock grazing appears to have minor effect.

In the forested ecosystems on the Medicine Bow National Forest most lichen species were ubiquitous. Differences in distribution appear to be mainly contolled by surface moisture, humidity, and substrate. Absorption and loss of water by lichens is strictly a physical process, at the mercy of temperature, humidity and wind. Low humidity and high wind speeds are especially important microclimate factors in southern Wyoming and appear to be major factors in limiting the distribution of lichen species. Thus, although there may be appropriate substrate, mosses may not grow and lichens may not be able to establish and persist. Thus protection from dessication is a key factor issue in the establishment and development of many kinds of lichen communities within forests in the Medicine Bow National Forest.

Eversman et al (1987) found a paucity of epiphytic lichens in the forests of Yellowstone National Park. They suggested that the cold continental climate of Yellowstone and surrounding area was a possible major contributing factor to low epiphytic lichen populations. Elevation and snow cover can also limit lichen distribution. Gough (1975) found that epiphytic lichens on subalpine fir were absent above about 10,900 feet in Rocky Mountain National Park. He suggested that atmospheric moisture (fog and absolute humidity) were limiting factors in epiphyte distribution. The elevational transition between relatively rich and relatively poor bark lichen floras in spruce-fir forest was about 10,000 feet (3050m). Trunk and branch lichen flora remained fairly constant over elevation gradients in Gough's study. He suggested that bark exfoliation, in addition to other bark characteristics and animal activity, might be an important limiting factor in determining which tree speices support lichen flora.

The conditions for lichen establishment in forests, appears to take more than 50 years. Clearcuts of approximately that age do not contain many species or much cover of lichens. Partial overstory removal and two or three step shelterwood silviculture also decreases lichen species diversity, but not as much as clearcutting.

In the summer of 1994, quantitative samples of *Bryoria fuscescens, Usnea hirta* and *Xanthoparmelia cumberlandia* were collected from Savage Run Wilderness to monitor air quality in Region 2 (Musselman, 1994). The GLEES Research Site was searched but these species were not found. While these species are distributed worldwide in the northern hemisphere, they have a sporadic distribution on the Medicine Bow National Forest. *Bryoria* and *Usnea* are epiphytic lichens which occur mainly on subalpine fir and Engelmann spruce. *Usnea* is sporadic in occurrence, and *Bryoria* is hard to find. Factors influencing this pattern are not clearly understood, but the effects of tie hacking and past fires with their concomitant effects on forest species, age, canopy structure, surface moisture and humidity levels are likely contributors to the erratic disribution pattern of these otherwise common forest tree lichens.

The conclusion from the lichen survey is that the area covered by lichens and the habitat available to them has been affected since the early 1800s. Tie hacking, which selectively removed mostly lodgepole pine and did not result in wholesale ground disturbance or canopy removal probably had less effect on lichen diversity and distribution that current clearcutting, rollerchopping and thinning, especially in spruce-fir forest between about 8800 feet and 10,000 feet.

By possibly encouraging populations of subalpine fir, tie-hacking may have increased populations of some lichen species. However, fires which occurred during the time period of about 1850 to 1910 did remove lichens from large areas. Some species have returned, especially where forest structure contains a large subalpine fir component and there is considerable canopy complexity and shading of the ground to retain moisture. Clearcutting severely removes lichens; partial cutting causes a loss of most species found in closed-canopy forests; burning removes all lichens. Lichen recovery in unburned, clearcut sites appears to begin in about 30 to 50 years.

Thanks are due to Dr. William Moir (Rocky Mountain Forest And Range Experiment Station); Dr. Martha Christiansen (U. WY Botany Dept., retired); Dr. Steven Miller (U. Wyoming Botany Department); Dr. Sam Sushan (U. of Colorado, Boulder, retired) and Dr. Larry St. Clair, (Brigham Young University, Herbarium of Non-Vascular Cryptogams) for review and helpful comments on this Appendix. The assistance of Sally Tinker, Bill Brenneman and Tim Chumley is gratefully acknowledged for field work, lichen identification and technical support.

DOCUMENTATION FOR TABLE AP7.2

The species list in Table AP7.2 is based on the following sources:

1. A review of lichen collections at the Rocky Mountain Herbarium, University of Wyoming, Laramie, WY. This included the University of Colorado Exsiccati Collection and the U. S. Forest Service Collection.

2. Manning, B. P. 1936. **Lichens of Albany County, Wyoming. Department of Botany.** University of Wyoming Master's Thesis

3. Personal communication with, and collection records of, Mr. William Brenneman of Jelm, Wyoming.

Nomenclature in Table AP7.2 follows Egan (1991).

Documented species of lichens in the Medicine Bow Mountains, the Sherman Mountains and nearby areas outside the forest boundary ar listed in Table AP7.2. Most specimens from the Medicine Bow Mountains are from the vicinity of Lake Marie and the University Science Camp on the Snowy Range Highway. Collections from the Sherman Mountains include the Vedauvoo Area, areas with calcareous rock or sandstoneand the Hawks ranch locality (Manning's collections, 1935-36) about 20 miles south to southwest of the Sherman Mountains area of the Medicine Bow National Forest, near the Wyoming/Colorado line, east of US 287 near Tie Siding, WY. The Dale Creek watershed, which heads on the Medicine Bow National Forest south of Pole Mountain traverses the Hawks Ranch area.

Payson's 1924 collections were in the same general area, but extended a few miles south into Colorado. Nine species on the list are from the Hawks Ranch and one species is from Payson's collections. Although these nine species are not specifically documented for the Medicine Bow National Forest Administrative area, they are likely to be found within the Forest boundary in the future, since they are common species. They have been included on the list in Table AP7.2. Few species from the Sierra Madre and Laramie Mountains are documented at this time.

Specimens in the Rocky Mountain Herbarium Collection date back to the mid-1890's when Dr. Aven Nelson collected in the Laramie Hills, Centennial Valley and Centennial Hills. Synonyms for some of these were not available.. Several other individuals collected near the turn of the century and for the first two decades of the 1900s. From Sept. 1936 until March of 1936, Beverly Pierce Manning studied lichens in Albany County between Lake Marie and the University

Science Camp area in the Snowy Range and the Laramie Hills, Vedauvoo area and south to the Colorado/Wyoming border under the direction of Dr. Wilhelm G. Solheim. Her specimens are documented in the herbarium and listed in her thesis. Her collections comprise most of the records in Table AP7.2.

The University of Colorado Exsiccati collection includes U.S. Forest Service collections of lichens from many National Forests in the Western U.S. These records, as well as recent collections from Mr. William Brenneman of Jelm, WY, were included on the lichen species list. Mr. Brenneman was trained in lichenology for air pollution monitoring and has spent about 13 years collecting and identifying specimens from the Medicine Bow National Forest. He has been assisting the U.S. Forest Service in the use of lichens for air pollution biomonitoring in Region 2.

Other collections which have not been searched for lichens found on the Medicine Bow National Forest, but which are known or likely to have specimens from here are: The Illinois Natural History Survey Museum (University of Illinois); The University of Nebraska Herbarium; the Herbarium of Non-vascular Cryptogams at Brigham Young University, Provo, Utah.

At this time, only one documented specimen is known from the Sierra Madre Mountains. Several old collections exist from Laramie Peak. Thus this list represents mainly the Sherman Mountains and Medicine Bow Mountains.

LITERATURE CITED

Brown, D.H. and R.M. Brown. 1991. Mineral cycling and lichens: the physiological basis. The Lichenologust 23(3): 293-308

Egan, R.S. 1991. Changes to the "A fifth checklist of the lichen-forming, lichenicoulous and allied fungi of the Continental United States and Canada." Edition III The Bryologist 94(4):396-400.

Eversman, S., Johnson, C. and D. Gustafson. 1987. Vertical distribution of epiphytic lichens on three tree species in Yellowstone National Park. The Bryologist 90:212-216.

Eversman, S. 1990. Lichens of Yellowstone National Park. The Bryologist 93(2):197-205.

Galun, M. 1988. **Handbook of Lichenology.** Volumes 1,2,3. CRC Press Boca Raton, FL

Gunther, R.T. 1934. **The Greek Herbal (Materia Medica) of Dioscorides, illustrated by a Byzantine AD 512** Englished by John Goodyer, AD 1655. Oxford University Press

Hale, M.E. 1969. **How to Know the Lichens.** Wm. C. Brown Company Dubuque, Iowa

Hale, M.E. 1974. **The Biology of Lichens.** American Elsevier Publishing Co London

Hale, M.E. 1982. Lichens as bioindicators of air pollution in the Flat Tops Wilderness Area, Colorado Final Report: Forest Service Contract No. OM R2-81-SP35 Denver, CO

Hale, M.E. and M. Cole. 1988. Lichens of California. California Natural History Guides 54. University of California Press

Huckaby, L.S. 1993. **Lichens as Bioindicators of Air Quality.** USDA Forest Service General Technical Report RM-224

Kershaw, K.A. 1985. **Physiological Ecology of Lichens.** Cambridge University Press

Knops, J.M.H., Nash, T.H. III, Boucher, V.L. and W.L. Schlesinger. 1991. Mineral cycling and epiphytic lichens: Implications at the ecosystem level. The Lichenologist 23(3):309-322

L'Obel, M. 1576. **de Plantarum Seu Stirpium Historia.** Antwerp

Manning, B. P. 1936. Lichens of Albany County, Wyoming.Department of Botany University of WyomingMaster's Thesis

Musselman, R. 1994. Personal Communication Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO

Nash, T.H. and V. Wirth. 1988. **Lichens, Bryophytes and Air Quality**. J. Cramer Berlin- Stuttgart

Pike, L.H. 1988. The importance of epiphytic lichens in mineral cycling. The Bryologist 81(2):247

Popovich, S.J., Shepperd, W.D., Reichert, D.W. and M. A. Cone. Flora of the Fraser Experimental Forest, Colorado USDA Forest Service General Technical Report RM-233 Fort Collins, CO

Puckett, K.J. 1988. Bryophytes and lichens as monitors of metal deposition IN: **Lichens, Bryophytes and Air Quality** Bibliotheca Lichenologica Band 30 J. Cramer Publishers Berlin

Richardson, D.H.S. 1974. **The Vanishing Lichens**. Hafner Press New York.

Rosenstreter, R. 1993. Vagrant lichens in North America. The Bryologist 96(3):333-338.

Routt/Medicine Bow National Forest Media Release. January 27, 1995 Steamboat Springs, CO

Seaward, M.R.O. 1977. **Lichen Ecology**. Academic Press

St. Clair, L. and J.R. Johansen. 1993. Introduction to the Symposium on Soil Crust Communities. Great Basin Naturalist 53(1):1-12

St. Clair, L. and C.C. Newberry. 1993. Lichen biomonitoring program and air quality baseline in selected sites of the Bridger Wilderness Area, Bridger-Teton National Forest. final Report. Unpublished reported prepared for the U.S. Forest Service Region 4. Odgen, Utah

Tschermak-Woess, E. The Algal Partner. In: Galun, M. 1988. Handbook of Lichenology. Volume 2 IIB pages 39-92. CRC Press Boca Raton, FL

Wetmore, C.M. 1967. Lichens of the Black Hills of South Dakota and Wyoming.Publications of the Museum Vol 3(4) Michigan State University

Vitt, D.H., Marsh, J.E. and R.B. Bovey. 1988. **Mosses, Lichens, and Ferns of Northwest North America**. University of Washington Press Pullman, WA

TABLE AP7.1 Characteristics of lichens known from collections prior to 1994 on the Medicine Bow National Forest.

Characteristic	Number of Species
Life Form	
Crustose	37
Foliose	38
Fruticose	19
Substrate	
Rock	39
Bark	20
Soil	15
Decaying wood	17
Dry wood	2
Vagrant	2
Biogeographical Affinity (for 51 species)	
Arctic-Boreal	29
Pan-Boreal	11
Pan-North American	4
Pan-Temperate	3
Western-Temperate	2
Arid-Southwesterm	1
Grasslands	1
Regional Distribution	
Black Hills	58 out of 405
Yellowstone	56 out of 186
Flattops Wilderness	42 out of 137
Wind River Mountains	35 out of 149
Fraser Experimental Forest	18 out of 54
Common to MBNF and other areas	6 species
Local Distribution	
Medicine Bow Moutains	66 out of 95 species
Sherman Mountains	50 out of 95 species
Both areas	18 species

KEY TO TABLE AP7.2

Column Headings:

SUBSTRATE

Abla = Abies lasiocarpa (subalpine fir)
Pico = Pinus contorta (loegepole pine)
Pien = Pice engelmannii (Engelmann spruce)
Psme = Pseudotsuga menziesii (Douglasfir)
Jusc = Juniperus scopulorum (Rocky Mtn. juniper)

SM = Sherman Mts.
MB = Medicine Bow Mts.

Lichen distributions
BH (B) = Black Hills, South Dakota
YEL (Y) = Yellowstone National Park, Wyoming
WR (W) = Wind River Mountains
FT (F) = Flattops area, Colorado
FR (R) = Fraser Experiment Forest, CO

FORM = life form
CR = crustose
FO = foliose
FR = fruticose
SQ = squamulose

HABIT= nitrogen fixation ability
N = nitrogen fixer (usually due to *Nostoc)*
V = vagrant

DIS = phytogeographic affinity (selected species, after (Wetmore, 1967)
AB = Arctic-Boreal - Species which occur above the Arctic Circle, northern NA and in the mountains
PB = Pan-Boreal - Species occuring south of the Arctic tundra, northern North American and the mountains
PN = Pan-North American - widespread from the Arctic to the southern U.S.
PT = Pan-Temperate - Species from south of the Arctic tundra to the southern U.S.
WT = Western temperate - Same as Pan-temperate but Black Hills is eastern limit.
ASW = Arid Southwestern - Characteristic of or endemic to the southwestern U.S.
GR = Characteristic of Great Plains grasslands

TABLE AP7.3 Lichens collected in clearcuts, adjacent unharvested stands and unharvested control sites from the inventory of biological diversity in clearcuts (Appendix 16). The first four categories refer only to unharvested sites. Lichens found in sites clearcut since 1950 are in the category (Disturbed only".

Ordination Group	1				2			3		4			5		6				7		8			9	10
Stands	1	6	5	31	19	20	30	8	28	11	15	21	53	65	37	40	42	47	22	25	24	54	58	57*	39
(MOST STANDS)																									
Cladonia cariosa	x	x	x	x			x	x	x	x	x	x		x	x	x	x	x	x	x			x	x	
Peltigera rufescens	x		x		x	x	x	x	x	x				x		x	x	x	x		x				
(MOSTLY TLP)																									
Parmeliopsis hypertopa			x																						
Physcia adscendens			x																x						
(TLP AND TSF)																									
Buellia punctata			x	x									x	x					x						
Caloplaca holocarpa				x									x			x									
Candelariella deflexa			x	x									x	x					x						
Lecanora carpinea			x										x												
Lecanora impudens			x	x									x	x											
Lecidella euphorea			x	x									x	x					x			x			
Melanelia exasperatula			x	x		x							x	x		x									
Melanelia elegantula			x	x		x							x	x		x									
Parmeliopsis ambigua			x											x											
Parmeliopsis hypertopa								x																	
Usnea lapponica			x			x							x	x		x			x						
Xanthoria polycarpa			x			x		x			x		x												
(TSF)																									
Bryoria fuscescens													x												
Physcia													x												
(DISTURBED ONLY)																									
Peltigera aphthosa													x			x							x	x	
Peltigera rufescens						x										x			x	x	x				
Physcia aipola											x														
Xanthoparmelia spp.							x																		
Xanthoria fallax																			x						

TABLE AP7.2 Lichens of the Medicine Bow National Forest based on herbarium specimens and published lists. This table does not include species collected during the 1994 fieldwork which are in Table AP7.3.

2/21/95

GENUS	SPECIES	SUBSTRATE	SH	MB	BH	WR	YEL	FT	FR	NIT	DIST	FOR	SBST
Acarospora	cervina	quartz		MB	B						AB	CR	R
Acarospora	chlorophana	acidic rocks, soil	SH	MB	B	W	Y	F			AB	CR	R
Acarospora	schleicheri	acidic rocks, soil	SH		B		Y				AB	CR	R
Ahtiana	sphaerosporella	old wood stump		MB								FO	S
Arctoparmelia	centrifuga	acidic rocks										FO	R
Aspicilia	caesiocineria	rocks		MB	B	W	Y	F			PB	CR	R
*Aspicilia	calcarea	granite		MB	B			F			AB	CR	R
Aspicilia	cinerea	scree rocks		MB	B		Y				PB	CR	R
Aspicilia	laevata	greenstone basalt		MB	B						PB	CR	R
Bryoria	abbreviata	decorticate bark		MB			Y					FR	B
Bryoria	fremontii	old stump	SH	MB	B		Y				WT	FR	B
Bryoria	fuscescens	Abla,Pien,Pico		MB		W	Y	F				FR	B
Bryoria	implexa	spruce bark	SH									FR	B
Buellia	punctata	old hayrack	SH		B	W						CR	B
Buellia	turgescens	gneiss		MB								CR	R
Caloplaca	bolacina	sandy limestone	SH									CR	R
Caloplaca	holocarpa	Abla,Pien	SH	MB	B	W		F			AB	CR	B
Caloplaca	saxicola	acidic rocks	SH					F				CR	R
Candelaria	concolor	bark		MB	B		Y				PT	FO	B
Cetraria	cucullata	tundra	SH	MB								FR	S
Cladonia	cariosa	stump in moss		MB	B		Y	F	R		AB	CR	D
Cladonia	carneola	old logs		MB	B		Y	F			AB	FR	L
Cladonia	cervicornis ssp.verticillata	soil over moss	SH		B		Y		R		PB	FR	D
Cladonia	chlorophea	soil/moss		MB	B	W	Y	F	R		PN	FR	D
Cladonia	cornuta	soil/moss		MB								FR	D
Cladonia	fimbriata	rotted stump		MB	B	W	Y	F			AB	FR	
Cladonia	gracilis	soil/moss		MB	B			F	R		AB	FR	D
Cladonia	phyllophora	soil/moss		MB								FR	D
Cladonia	pyxidata	soil/moss		MB	B	W	Y	F	R		AB	FR	D
Cladonia	turgida	soil/moss	SH									FR	D
Coelocaulon	aculeatum	tundra		MB			Y					FR	S

GENUS	SPECIES	SUBSTRATE	SH	MB	BH	WR	YEL	FT	FR	NIT	DIST	FOR	SBST
Collema	polycarpon	limestone	SH					F		N		FO	R
Cyphelium	tigillare	old wood	SH		B		Y				PB	CR	L
Dermatocarpon	luridum	waterline/rocks		MB	B						PB	FO	R
Dermatocarpon	miniatum	granite	SH		B	W	Y	F			AB	FO	R
Dermatocarpon	moulinsii	granite	SH		B							FO	R
Dimelina	oreina	acidic rock	SH	MB	B	W	Y	F			AB	CR	R
Diploschistes	scruposus	soil and moss	SH	MB	B	W	Y	F			AB	CR	S
Hyperphyscia	adglutinata	Jusc	SH									FO	B
Lecanora	allophana	moss/soil	SH	MB				F				CR	D
Lecanora	cenisia	granite	SH		B	W	Y				PB	CR	R
Lecanora	cupressii	old wood		MB								CR	D
Lecanora	iowensis	sandstone	SH	MB								CR	R
Lecanora	muralis	acidic rocks	SH	MB	B	W	Y	F			PB	CR	R
Lecanora	novomexicana	sandstone	SH		B	W	Y	F			ASW	CR	R
Lecanora	varia	old wood		MB	B	W	Y	F			PB	CR	D
Lecidia	limosa	moss/old woods		MB								CR	D
Lecidia	plana	quartz/orthoclase		MB	B			F				CR	R
Lecidia	tessellata	granite	SH		B	W	Y	F			AB	CR	R
Leptogium	saturninum	granite	SH		B		Y		R		AB	FO	R
Letharia	vulpina	Pico, Psme	SH	MB	B	W	Y				WT	FR	B
Melanelia	exasperatula	Jusc bark	SH			W						FO	B
Melanelia	elegantula	trees	SH				Y					FO	B
Melanelia	olivacea	Psme bark	SH									FO	B
Melanelia	subolivacea	Psme,Abla,Pien	SH	MB			Y	F				FO	B
Ochrolechia	subpallescens	Abla bark		MB								CR	B
Pannaria	pezizoides	moss on rock	SH	MB	B	W				N	AB	CR	D
Parmeliopsis	ambigua	conifer bark		MB	B	W	Y		R			FO	B
Peltigera	aphthosa	soil		MB	B		Y	F	R	N	AB	FO	S
Peltigera	canina	soil/moss		MB	B	W	Y	F	R	N	PN	FO	S
Peltigera	didactyla	dry soil	SH	MB	B	W				N	PN	FO	S
Peltigera	rufescens	moist soil,woods			B	W	Y		R	N	PN	FO	S
Peltigera	venosa	dry soil		MB	B	W	Y	F	R	N	AB	FO	S
Pertusaria	glomerata	soil/Selaginella	SH									FR	S

GENUS	SPECIES	SUBSTRATE	SH	MB	BH	WR	YEL	FT	FR	NIT	DIST	FOR	SBST
Physcia	adscendens	sagbrush		MB	B		Y	F			PB	FO	B
Physcia	aipolia	Pifl, Psme		MB	B		Y	F			PT	FO	B
Physcia	dubia	antler, alk rock		MB	B	W	Y	F			AB	FO	R
Physcia	stellaris	Pifl. Psme		MB	B		Y	F			PT	FO	B
Physica	tenella	old tooth		MB								FO	R
Psora	rubiformis	claysoil/rock	SH					F				CR	S
Psora	russellii	quartz	SH				Y	F				CR	R
Psoroma	hypnorum	soil		MB				F	R	N		SQ	S
Rhizocarpon	geographicum	quartz		MB	B	W	Y	F	R		AB	CR	R
Rhizoplaca	chrysoleuca	granite	SH	MB	B	W	Y	F			AB	FO	R
Rhizoplaca	haydenii	loose on soil	SH									FO	V
Rhizoplaca	melanophthalma	tundra		MB	B	W	Y	F			AB	FO	R
Rinodina	turfacea	Selag/Soil	SH					F				CR	S
Solorina	crocea	moss, soil		MB		W	Y		R			FO	D
Solorina	spongiosa	peaty bank, soil		MB								FO	D
Staurothele	clopima	sandstone	SH				Y	F			AB	CR	R
Stereocaulon	tomentosum	soil under Pico		MB	B		Y		R	N	AB	FR	S
*Umbilicaria	caroliana	granite	SH	MB								FO	R
Umbilicaria	deusta	granite	SH		B	W	Y		R		AB	FO	R
Umbilicaria	hyperborea	rockslides, rock	SH	MB	B	W	Y	F	R		AB	CR	R
Umbilicaria	vellea	cliffs.,rock	SH		B	W	Y		R		AB	FO	R
Umbilicaria	virginis	rock	SH				Y	F				CR	R
Usnea	hirta	conifers	SH	MB	B	W	Y					FR	B
Verrucaria sp		acid rocks		MB	B							CR	R
Xanthoparmelia	chlorocroa	vagrant		MB	B		Y	F			GR	FO	V
Xanthoparmelia	conspersa	granite	SH	MB	B							FO	R
Xanthoparmelia	cumberlandia	rocks	SH	MB		W	Y					FO	R
Xanthoparmelia	plittii	granite		MB	B		Y					FO	R
*Xanthoparmelia	taractica	soil		MB			Y					FO	S
Xanthoria	candelaria	log		MB	B	W	Y				AB	CR	D
Xanthoria	elegans	limestone grave	SH	MB	B	W	Y				AB	FO	R
Xanthoria	polycarpa	Abla,Pien	SH	MB	B		Y	F			PB	CR	B

APPENDIX 8

FUNGAL SPECIES BIOLOGICAL DIVERSITY

Fungi are a poorly known, but important, group of organisms contributing to the biological diversity of the Medicine Bow National Forest. Fungi do not have chlorophyll. Most species derive their nutrition from breakdown of dead organic materials (saprophytic fungi) or from living organisms (parasitic fungi). Mutualistic associations of fungi with algae or cyanobacteria form liches. Other fungi associate mutualistically with root tips of vascular plants (mycorrhizae). Mushrooms (macrofungi) are fruiting bodies (sporocarps) which can show the presence of saprophytic fungi, parasitic fungi or symbiont fungi (mycorrhizae).

The Solheim Mycological Herbarium is located at the University of Wyoming, but unfortunately information on collections and locations from the Medicine Bow National Forest are not readily available in summarized form. Several Master's studies on macrofungi and soil fungi have been done in the past:

Arenberg, F.F. 1939. The Agaricaceae of the Medicine Bow Mountains of Wyoming. Master's Thesis. U. WY

Cassidy, A.M. 1970. The Boletaceae of the Medicine Bow National Forest of Wyoming. Master's Thesis. U. WY

Rall, G. 1962. Soil fungi of the alpine zone of the Medicine Bow Mountains. Master's Thesis. U. WY.

Many kinds of parasitic fungi are known. Some are important forest pathogens. Comandra blister rust, *Cronartium comandrae*, causes stem and branch cankers, spiketops, and death of seedlings in lodgepole pine. A forb, pale comandra (*Comandra umbellata*) is an alternate host needed to complete the life cycle of the rust. Recent work by Geils and Jacobi (1987), Jacobi (1993) and Jacobi et al (1993) have identified this parasitic fungus as a potentially serious threat to lodgepole pine seedling survival and growth on the Medicine Bow and Shoshone National Forests.

Armillaria spp. are a group of parasitic root fungi which can infect pines, primarily lodgepole pine and ponderosa pine, causing reduction of shoot growth, changes in foliage health, crown dieback and butt rot. Fungal infection with *Armillaria* can also predispose trees to infestation by other parasitic or herbivorous organisms (Shaw and Kile, 1991). *Armillaria* is not a serious fungal diease on the Medicine Bow National Forest, perhaps due to the dry, cold climate (Geils, personal communication).

Lodgepole pine can also be infected with western gall rust, *Endocronartium harknessii*. Tomentosus root rot, *Inonotus tomentosus*, infects Engelmann spruce. Broom rust of spruce (*Chrysomyxa*) has kinnikinnik as an alternate hose. On subalpine fir, broom rust (*Melampsorella*) alternately infects chickweed (*Stellaria* sp.) (Hepsting, 1971). These are not of serious economic importance here.

Many other kinds of parasitic fungi occur on the Medicine Bow National Forest, for example aspen cankers (*Cytospora*) and sooty bark canker (*Encoelia*). *Marssonina* causes leaf spot on aspen. Other leaf spot fungi occur on willows. An unidentified organism, probably a fungus has caused severe mortality of *Ribes cereum* (wild currant) north of the Virginia Dale area in Colorado and in the Sherman Mountains in the past three years (von Ahlefeldt, personal observation).

Other parasitic fungi in the genus *Ceratocystis*, which are severely pathogenic, associate with bark beetles (*Dendroctonus* and *Ips*). Brown felt fungi (*Herpotrichia* spp., infect conifers benath snow, covering foliage with a brown sticky substance.

Ongoing work, mainly on mycorrhizal fungi, is being done by Dr. Steven Miller (Department of Botany, University of Wyoming) and Dr. Steven Williams (Department of Plant, Soil and Insect Sciences, University of Wyoming). Mycorrhizal fungi associate with root tips of many plants including most conifers and shrubs. These fungi enable seedling eatablishment and survival and are essential for some types of nutrient uptake.

The list of macrofungi in Table AP8.1 was provided by Dr. Steven Miller. The Foxpark Study Sites are in the southern Medicine Bow Mountains at an elevation of about 9000 feet. This is a partial list of fungi of the Medicine Bow Mountains. It does not, of course include fungal species found in other mountain ranges (Sierra MAdre, Sherman Mountains or Laramie Mountains) within the Medicine Bow National Forest, nor does it include species of higher altitudes, canyons or from ecosystems bordering the desert on the west or the plains on the east. Comparable lists for the Pacific Northwest have over 200 species (Steve Miller, personal communication).

Knowledge of occurrence, ecology and functional roles of fungi is elementary at this time. The list in this appendix is a start in assembling this information. Further work needs to be done to review, update names and organize existing information from the theses done on the Medicine Bow National Forest, and from specimens in the Solheim Collection at the University of Wyoming. Additional collections of pathogenic fungi from the Medicine Bow National Forest can be found in the Plant Pathology Collection at the Rocky

Mountain Station in Fort Collins. Because fungi are important ecosystem components of old growth forests, knowledge of species occurrence and ecological requirements may help in identifying and monitoring old growth.

LITERATURE CITED

Geils, B.W. Plant Pathologist - Rocky Mountain Station - Fort Collins, CO

Geils, B.W. and W.R. Jacobi. 1987. Comandra blister rust: A threat to lodgepole pine. IN: Management of Subalpine Forests: Building of 50 years of Research. USDA Forest Service General Technical Report RM-149:216-217

Hepsting, G.H. 1971. **Diseases of Forest and Shade Trees of the United States.** USDA Handbook 386 Washington, D.C.

Jacobi, W.R. 1993. Insects emerging from lodgepole pine infected by Comandra blister rust. USDA Forest Service Research Note RM-519

Jacobi, W.R., Geils, B.W., Taylor, J.E. and W.R. Zentz. 1993. Predicting the incidence of Comandra blister rust on lodgepole pine: site, stand and alternate host influences. Phytopathology 83(6):630-637.

Shaw, C.G. and G.A. Kile. 1991. **Armillaria Root Disease.** USDA Forest Service Handbook 691 Washington, D.C.

TABLE AP8.1 List of 87 macrofungi collected at Foxpark Study Sites 1988-1991 (Courtesy of Dr. Steven Miller, Department of Botany, University of Wyoming).

Agaricus sp.	*Lactarius scrobicularis*
Amanita muscaria	*Lycogala epidendrum*
Amanita vaginata	*Lycoperdon sp.*
Boletus edulis	*Lycophyllum montanum*
Brauniellula nancyae	*Mariasmius sp.*
Cantharellus cibarius	*Martellia sp.*
Chroogomphus rutilus	*Morchella sp.*
Clavariadelphus sp.	*Mycena* (4 species)
Clitocybe albirhiza	*Nolanea sp.*
Clitocybe sp.	*Pholiota sp.*
Cortinarius (17 species)	*Ramaria sp.*
Discina sp.	*Rhizopogon ochraceorubens*
Galerina sp.	*Rhizopogon rubescens*
Geophora cooperi	*Russula albonigra*
Hebeloma mesophaeum	*Russula brevipes*
Hebeloma (4 species)	*Russula claroflara*
Hydnum imbricatum	*Russula cyanoxantha*
Hygrophorus chrysodon	*Russula mustelina*
Hygrophorus erubescens	*Russula olivacea*
Hygrophorus gliocyclus	*Russula xerampelina*
Hygrophorus olivaceo-alba	*Sarcosoma latahensis*
Hygrophorus ponderosus	*Suillus brevipes*
Hymenogaster sublilucina	*Suillus tomentosus*
Inocybe geophila	*Tricholoma flavovirens*
Inocybe lonicera	*Tricholoma focale*
Inocybe (2 species)	*Tricholoma myomyces*
Laccaria montana	*Tricholoma roseoacerbum*
Lactarius deliciosus	*Tricholoma saponaceum*

APPENDIX 9

ANIMAL SPECIES BIOLOGICAL DIVERSITY

These lists were prepared from information supplied by District Biologists on the Brush Creek, Douglas, Hayden and Laramie Ranger Districts, and other sources listed below. The information in Table AP9.1 summarizes Table AP9.3 (species lists by mountain area) in different ways.

Table AP9.2 lists species which were historically present or for which there is insufficient information to determine presence. Further information can be found in Chapter 8 and Appendix 10 (Neotropical Migratory Birds).

Species listed in Table AP9.3 are believed to be present on the Medicine Bow National Forest. Information on fisher, wolverine and lynx does not permit verification of presence because of unconfirmed observation records, but these species are not believed to be present. Fisher observations are not reported for Colorado or southern Wyoming (1961-1993); wolverine observations for the same period are reported from areas in Colorado adjacent to the Medicine Bow National Forest; two lynx observations were reported on the lower Medicine Bow, 1961-1982, and one observation (1983-1994) in the Laramie Range according to Ruggiero et al (1994).

The Fine Filter report prepared by Mills and Neighbors (1995 - Wyoming Natural Diversity Database - The Nature Conservancy) presents records for selected species as recorded by The Wyoming Natural Diversity Database (WYNDD). WYNDD does not recognize sightings for some species from Wyoming State Game and Fish Department Records, and additional information was gathered for the report from interviews. The information presented in this appendix does not include the information in Mills and Neighbors (1995).

SOURCES OF INFORMATION:

USFS. 1993. **White Swan-Holmes Environmental Assessment** Medicine Bow National Forest Laramie, WY

USFS. 1993. **Strawberry Gulch Environmental Assessment** Medicine Bow National Forest Laramie, WY

Lists of vertebrate species exclusive of fish and amphibians provided by Jerry Mastel and Tim Byer

Lists of fish and amphibians provided by Greg Eaglin (Zone Fish Biologist - Brush Creek-Hayden Districts)

Personal communication with:
Clay Speas, (Forest Fish Biologist)
Joel Harper (Laramie District)
Jerry Mastel (Brush Creek District),
Tim Byer (Douglas District)
Shirlene Haas (Hayden District)
Dr. Hank Henry (USFS Research- Laramie)
Mr. Reg Rothwell (WY Game and Fish Dept.)
Tom Cartwright (Forest Wildlife Biologist)

Data base information current through May, 1994 from Wyoming Game and Fish Department and the Wyoming Natural Diversity Database, The Nature Coservancy, Laramie, WY.

Federal Register. Nov. 15, 1994 Endangered and Threatened Wildlife and Plants: Animal Candidate Revies for listing as Endangered and Threatened Species: Proposed Rule Vol 59(1):58982-59028

Mills, S.H. and M. Neighbors. 1995. **Intensive data gathering project (Fine Filter Analysis) for occurrences of rare, threatened, endangered and sensitive species in Sections M331H and M331I, North Central Highlands and Northern Parks and Ranges in Wyoming.** Wyoming Natural Diversity Database of THE Nature Conservancy Laramie, WY

Ruggiero, L.F., Aubrey, K.B., Buskirk, S.W., Lyon, L.J. and W.J. Zielinski. 1994. **The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in the Western United States.** USDA Forest Service General Technical Report RM-254 Fort Collins, CO.

TAXONOMIC SOURCES:

American Ornithologists' Union. 1983. **Check-list of North American Birds.** Sixth Edition. American Ornithologists' Union Printed by Allen Press Lawrence, KA

Jones, J.K., Jr., Carter, D.C., Genoways, H.H., Hoffmann, R.S., Rice, D.W. and C. Jones. 1986. **Revised Checklist of North American Mammals North of Mexico.** Occasional Papers of the Museum Texas Tech University 107:1-22

TABLE AP9.1 Vertebrate animal species of the Medicine Bow National Forest

	Total	T&E	CAND	R-2 Sensitive	MIS**
FISHES	24	0	1	2	7
AMPHIBIANS	6	0	1	4	2
REPTILES	19	0	1	1	1
BIRDS	227	2	11	25	16
MAMMALS	75	0	5	7	9
TOTAL	351	2	19	39	35

** MIS means Management Indicator Species (1985 Forest Plan)

TABLE AP9.2 **Species historically present or for which there is insufficient evidence as to present occurrence**

FISHES	
arctic grayling	
sturgeon chub	
MAMMALS	
spotted bat	
Preble's jumping mouse	
yellow-pine chipmunk	
gray wolf	Historical
black-footed ferret	Historical
grizzly bear	Historical
fisher*	
wolverine	
lynx*	
swift fox	
ringtail	
BIRDS	
whooping crane	
western snowy plover	
black-backed woodpecker	
Harlequin duck	

* controversial record

TABLE AP9.3 VERTEBRATE ANIMAL SPECIES LIST FOR THE MEDICINE BOW NATIONAL FOREST

The table contains information under the following headings:

Mountain Range
- **SM** = Sierra Madre (Hayden Ranger District)
- **SR** = Snowy Range (Medicine Bow Mountains of the Laramie Ranger District and Brush Creek Ranger District)
- **SH** = Sherman Mountains (Pole Mountain Area of the Laramie Ranger District)
- **LP** = Laramie Mountains (Douglas Ranger District)

Common Name
Family
Scientific Name
TEC status* — **T**hreatened, **EN**dangered **C1, C2, C3** (Candidate)

SENsitive Species Status (Region 2) — **S** means it is on the 1994 R-2 list

MIS Management Indicator Species
- **FE** = Featured species
- **RE** = Recovery species
- **EC** = Ecological

NEOtropical migrant status
- **A** = breeds in the U.S.; winters south of U.S.
- **B** = breeds and winters in U.S.

CONServation priority status — **C**= identifier for CONS Neotropical migrant species on the R-2 ranking lists which rank 4 or 5 for abundance and/or threats to breeding grounds. These are species whose habitat needs should receive particular attention. See Appendix on Neotropical Migratory Birds

Status Definitions

Candidate Species are identified by the US Fish and Wildlife Service. See Federal Register 59(219):58983-58984 for full explanation of status.

C1 - sufficient information exists in USFWS files on biological vulnerability and threat to support proposals to list the species as endangered or threatened. Consideration should be given to these taxa in environmental planning.

C2 - proposals for listing as threatened or endangered are possibly appropriate but persuasive data on biological vulnerability and threat are not currently available. Research is encouraged.

C3 - Not current candidates for listing for various reasons. There are no C3 fauna on the Medicine Bow Forest.

MEDICINE BOW NF ANIMAL SPECIES LIST

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO
				FISHES					
				Salmonidae					
SM	SR			Yellowstone cutthroat trout	*Onchorhynchus lewisii*		S		
SM	SR			Colorado River cutthroat trout	*Oncorhynchus clarkii*	C2	S	EC	
SM	SR	SH	LP	rainbow trout	*Oncorhynchus mykiss*			EC	
	SR			golden trout	*Onchorhynchus aguabonita*			EC	
SM	SR			Snake River cutthroat trout	*Onchorhynchus clarkii*			EC	
	SR			Bonneville cutthroat trout	*Onchorhynchus clarkii utah*			EC	
SM	SR	SH	LP	brook trout	*Salvelinus fontinalis*			EC	
	SR			splake	*hybrid*				
SM	SR		LP	brown trout	*Salmo trutta*			EC	
SM	SR			mountain whitefish	*Prosopium williamsoniii*				
				Catastomidae					
SM	SR			mountain sucker	*Catostomus platyrhynchus*				
SM	SR	SH		white sucker	*Catostomus commersoni*				
SM				bluehead sucker	*Catostomus discobolus*				
SM	SR			flannelmouth sucker	*Catostomus lattipinnis*				
	SR	SH		longnose sucker	*Catostomus catostomus*				
	SR			Cottidae					
SM				mottled sculpin	*Cottus bairdi*				
				Cyprinidae					
	SR		LP	longnose dace	*Rhinichthys cataractae*				
SM	SR			speckled dace	*Rhinichthys osculus*				
SM	SR		LP	creek chub	*Semotilus atromaculatus*				
SM	SR			roundtail chub	*Gila robusta*				
SM	SR			Bonneville redside shiner	*Richardsonicus balteatus*				
			LP	common carp	*Cyprinus carpio*				
				Centrarchidae					
			LP	green sunfish	*Lepomis cyanellus*				
				Gasterosteidae					
	SR			threespike stickleback	*Gasterosterus aculeatus*				
				AMPHIBIANS					
				Ambystomidae					
SM	SR	SH	LP	tiger salamander	*Ambystoma tigrinum*		S		
				Bufonidae					
SM	SR	SH	LP	boreal toad	*Bufo boreas*	C2	S	EC	
			LP	Rocky Mountain toad	*Bufo woodhousei*				
				Ranidae					
SM	SR	SH	LP	leopard frog	*Rana pipiens*		S		
	SR			wood frog	*Rana sylvatica*		S	EC	
SM	SR	SH	LP	boreal chorus frog	*Pseudacris triseriata*				
				REPTILES					
				Teiidae					
SM				prairie-lined racerunner	*Cnemidophorus sexilineatus*				
				Scincidae					
SM				many-lined skink	*Eumeces multiviragatus*				
				Iguanidae					
SM	SR			northern sagebrush lizard	*Sceloporus graciosus*				
SM	SR			red-lipped prairie lizard	*Sceloporus undulatus erythrocheilus*				
SM				northern prairie lizard	*Sceloporus undulatus garmani*				
SM	SR	SH	LP	eastern short-horned lizard	*Phrynosoma douglassi brevirostra*	C2			

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO
				Reptiles					
				Colubridae					
SM			LP	plains hognose snake	*Heterodon nasicus nasicus*				
SM	SR	SH	LP	smooth green snake	*Opheodrys vernalis*			EC	
SM			LP	eastern yellow-bellied racer	*Coluber constrictor flaviventris*				
SM	SR		LP	western smooth green snake	*Opheodrys vernalis blanchardi*			EC	
SM			LP	pale milk snake	*Lampropeltis triangulum multistrata*		S		
SM	SR		LP	bullsnake	*Pituophis melanoleucas sayi*				
SM	SR	SH		wandering garter snake	*Thamnophis elegans vagrans*				
SM	SR			common garter snake	*Thamnophis sirtalis*				
			LP	red-sided garter snake	*Thamnophis sirtalis parietalis*				
			LP	western terrestrial garter snake	*Thamnophis elegans*				
			LP	western plains garter snake	*Thamnophis radix*				
				Viperidae					
SM	SR	SH	LP	prairie rattlesnake	*Crotalus viridis*				
				Chelydridae					
SM	SR		LP	snapping turtle	*Chelydra serpentina*				
				Testudinidae					
			LP	painted turtle	*Chrysemys picta*				
				MAMMALS					
				Didelphidae					
		SH	LP	Virginia opossum	*Didelphis virginiana*				
				Soridicae					
SM	SR	SH	LP	masked shrew	*Sorex cinereus*				
	SR			pygmy shrew	*Sorex hoyi*		S		
SM	SR	SH	LP	Merriam's shrew	*Sorex merriami*				
SM	SR	SH	LP	dusky shrew	*Sorex monticolus*				
SM	SR	SH	LP	dwarf shrew	*Sorex nanus*		S	EC	
SM	SR	SH	LP	water shrew	*Sorex palustris*				
				Talpidae					
SM	SR	SH	LP	Eastern mole	*Scalopus aquaticus*				
				Vespertilionidae					
SM	SR	SH	LP	small-footed myotis	*Myotis ciliolabrum*	C2			
SM	SR	SH	LP	little brown myotis	*Myotis lucifugus*				
SM	SR	SH	LP	long-eared myotis	*Myotis evotis*	C2			
	SR	SH	LP	fringed-tailed myotis	*Myotis thysanodes*	C2	S		
SM	SR	SH	LP	long-legged myotis	*Myotis volans*	C2			
SM	SR	SH	LP	red bat	*Lasiurus borealis*				
SM	SR	SH	LP	hoary bat	*Lasiurus cinereus*				
SM	SR	SH	LP	silver-haired bat	*Lasionycteris noctivagans*				
SM	SR	SH	LP	big brown bat	*Eptesicus fuscus*				
SM	SR	SH	LP	Townsend's big-eared bat	*Plecotus townsendii*	C2	S		
				Ochotonidae					
SM	SR	SH	LP	pika	*Ochotona princeps*				
				Leporidae					
SM	SR	SH	LP	Nuttall's cottontail	*Sylvilagus nuttallii*				
SM	SR	SH	LP	desert cottontail	*Sylvilagus audubonii*				
SM	SR	SH	LP	snowshoe hare	*Lepus americanus*				
	SR	SH	LP	black-tailed jackrabbit	*Lepus californicus*				
SM	SR	SH	LP	white-tailed jackrabbit	*Lepus townsendii*				

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO
				Mammals					
				Sciuridae					
SM	SR	SH	LP	least chipmunk	*Eutamias minimus*				
SM	SR	SH	LP	Uinta chipmunk	*Tamias umbrinus*				
SM	SR	SH	LP	yellow-bellied marmot	*Marmota flaviventris*				
SM	SR	SH	LP	Wyoming ground squirrel	*Spermophilus elegans*				
SM	SR	SH	LP	golden-mantled ground squirrel	*Spermophilus lateralis*				
SM	SR	SH	LP	thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*				
SM	SR	SH	LP	white-tailed prairie dog	*Cynomys gunnisonii*				
SM	SR	SH	LP	fox squirrel	*Sciurus niger*				
SM	SR	SH	LP	red squirrel	*Tamiasciurus hudsonicus*				
				Geomyidae					
SM	SR	SH	LP	northern pocket gopher	*Thonomys talpoides*				
				Heteromyidae					
SM	SR	SH	LP	olive-backed pocket mouse	*Perognathus fasciatus*				
		SH	LP	plains pocket mouse	*Perognathus flavescens*				
SM	SR	SH	LP	Ord's kangeroo rat	*Dipodomys ordii*				
				Castoridae					
SM	SR	SH	LP	beaver	*Castor canadensis*			EC	
				Cricetidae					
SM	SR	SH	LP	western harvest mouse	*Reithrodontomys megalotis*				
	SR	SH	LP	plains harvest mouse	*Reithrodontomys montanus*				
SM	SR	SH	LP	deer mouse	*Peromyscus maniculatus*				
SM	SR	SH	LP	northern grasshopper mouse	*Onychomys leucogaster*				
SM	SR	SH	LP	bushy-tailed woodrat	*Neotoma cinerea*				
SM	SR	SH	LP	southern red-backed vole	*Clethrionomys gapperi*			EC	
SM	SR	SH	LP	heather vole	*Phenacomys intermedius*				
SM	SR	SH	LP	long-tailed vole	*Microtus longicaudus*			EC	
SM	SR	SH	LP	montane vole	*Microtus montanus*				
SM	SR	SH	LP	prairie vole	*Microtus ochrogaster*				
SM	SR	SH	LP	sagebrush vole	*Lemmiscus curtatus*				
SM	SR	SH	LP	muskrat	*Ondatra zibethicus*				
				Muridae					
SM	SR	SH	LP	house mouse	*Mus musculus*				
				Zapodidae					
SM	SR	SH	LP	meadow jumping mouse	*Zapus hudsonius*				
SM	SR	SH	LP	western jumping mouse	*Zapus princeps*			EC	
				Erethizontidae					
SM	SR	SH	LP	porcupine	*Erethizon dorsatum*				
				Canidae					
SM	SR	SH	LP	coyote	*Canis latrans*				
SM	SR	SH	LP	red fox	*Vulpes velox*		S		
				Ursidae					
SM	SR	SH	LP	black bear	*Ursus americanus*				
				Procyonidae					
SM	SR	SH	LP	raccoon	*Procyon lotor*				
SM	SR	SH	LP	ringtail	*Bassariscus astutus*		S		
				Mustelidae					
SM	SR	SH	LP	marten	*Martes americana*		S	EC	
SM	SR	SH	LP	ermine	*Mustela erminea*				
SM	SR	SH	LP	long-tailed weasel	*Mustela frenata*				
SM	SR	SH	LP	mink	*Mustela vison*				
SM	SR	SH	LP	badger	*Taxidea taxus*				
SM	SR	SH	LP	western spotted skunk	*Spilogale gracilus*				
			LP	eastern spotted skunk	*Spilogale putorius*				
SM	SR	SH	LP	striped skunk	*Mephitis mephitis*				

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO	CONS
				Mammals						
				Felidae						
SM	SR	SH	LP	mountain lion	*Felis concolor*					
SM	SR	SH	LP	bobcat	*Felis rufus*					
				Artiodactyla						
SM	SR	SH	LP	elk	*Cervus elaphus*			FE		
SM	SR	SH	LP	mule deer	*Odocoileus hemionus*			FE		
SM	SR	SH	LP	white-tailed deer	*Odocoileus virginianus*					
SM	SR			moose	*Alces alces*					
				Antilocapridae						
SM	SR	SH	LP	pronghorn	*Antilocapra americana*					
				Bovidae				FE		
SM	SR		LP	bighorn sheep	*Ovis canadensis*					
				BIRDS						
				Gaviidae						
SM	SR		LP	common loon	*Gavia immer*		S			
				Podicipedidae						
SM	SR	SH	LP	pied-billed grebe	*Podilymbus podiceps*					
			LP	horned grebe	*Podiceps auritus*					
SM	SR		LP	eared grebe	*Podiceps nigricollis*					
			LP	western grebe	*Aechmophorus occidentalis*					
			LP	Clark's grebe	*Aechmophorus clarkii*					
				Ardeidae						
SM	SR	SH	LP	American bittern	*Botaurus lentignosus*		S			
SM	SR	SH	LP	great blue heron	*Ardea herodias*					
SM	SR	SH	LP	black-crowned night heron	*Nycticorax nycticorax*					
				Threskiornithidae						
	SR			white-faced ibis	*Plegadis falcinellus*	C2	S			
				Anatidae						
			LP	snow goose	*Chen caerulescens*					
SM	SR	SH	LP	Canada goose	*Branta canadensis*					
SM	SR	SH	LP	American green-winged teal	*Anas crecca carolinensis*					
SM	SR	SH	LP	mallard	*Anas platyrhynchos*					
SM	SR	SH	LP	northern pintail	*Anas acuta*					
SM	SR	SH	LP	blue-winged teal	*Anas discors*					
SM	SR	SH	LP	cinnamon teal	*Anas cyanoptera*					
SM	SR	SH	LP	northern shoveler	*Anas clypeata*					
SM	SR	SH	LP	gadwall	*Anas strepera*					
SM	SR	SH	LP	American widgeon	*Anas americana*					
		SH	LP	canvasback	*Aythya valisineria*					
		SH	LP	redhead	*Aythya americana*					
SM	SR	SH	LP	ring-necked duck	*Aythya collaris*					
	SR	SH	LP	lesser scaup	*Athya affinis*					
			LP	oldsquaw	*Clangula hyemalis*					
SM	SR		LP	common goldeneye	*Bucephala clangula*					
			LP	Barrow's goldeneye	*Bucephala islandica*					
SM	SR		LP	bufflehead	*Bucephala albeola*					
SM	SR	SH	LP	Common merganser	*Mergus merganser*					
				Cathartidae						
SM	SR	SH	LP	turkey vulture	*Cathartes aura*				B	
				Pandionidae						
SM	SR		LP	osprey	*Pandion haliaetus*		S	EC		C

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO	CONS
				Birds						
				Accipitridae						
SM	SR		LP	bald eagle	*Haliaeetus leucocephalus*	EN		RE		
SM	SR	SH	LP	northern harrier	*Circus cyaneus*				B	C
SM	SR	SH	LP	sharp-shinned hawk	*Accipiter striatus*				B	C
SM	SR	SH	LP	Cooper's hawk	*Accipiter cooperii*				B	C
SM	SR	SH	LP	northern goshawk	*Accipiter gentilis*	C2	S	EC	B	C
SM	SR	SH	LP	Swainson's hawk	*Buteo swainsoni*				A	
SM	SR	SH	LP	red-tailed hawk	*Buteo jamaicensis*				B	
SM			LP	Harlan's hawk	*Buteo jamaicensis harlani*					
SM	SR	SH	LP	ferruginous hawk	*Buteo regalis*	C2	S		B	C
SM	SR	SH	LP	rough-legged hawk	*Buteo lagopus*					
SM	SR	SH	LP	golden eagle	*Aquila chrysaetos*				B	
				Falconidae						
SM	SR	SH	LP	American kestrel	*Falco sparverius*				B	
SM	SR		LP	merlin	*Falco columbarius*		S		A	
SM	SR		LP	peregrine falcon	*Falco peregrinus*	EN		RE	A	C
SM	SR	SH	LP	prairie falcon	*Falco mexicanus*				B	C
				Phasianidae						
SM	SR	SH	LP	chukar	*Alectoris chukar*					
SM	SR	SH	LP	blue grouse	*Dendragapus obscurus*			EC		
SM	SR		LP	sage grouse	*Centrocercus urophasianus*			EC		
SM	SR			white-tailed ptarmigan	*Lagopus leucurus*			EC		
SM				Columbian sharp-tailed grouse	*Tympanuchus phasianellus*	C2	S			
SM			LP	turkey	*Meleagris gallopavo*			FE		
				Rallidae						
SM	SR			Virginia rail	*Rallis limicola*					
SM	SR	SH		sora	*Porzana carolina*					
SM	SR	SH	LP	American coot	*Fulica americana*					
				Gruidae						
SM	SR			sandhill crane	*Grus canadensis*		S	EC		
				Charadiidae						
SM	SR	SH	LP	killdeer	*Charadrius vociferus*				B	
		SH	LP	mountain plover	*Charadrius monanus*	C1	S			
				Recurvirostridae						
SM	SR	SH	LP	American avocet	*Recurvirostra americana*					
				Scolopacidae						
			LP	greater yellowlegs	*Tringa melanoleuca*					
			LP	lesser yellowlegs	*Tringa flavipes*					
			LP	solitary sandpiper	*Tringa solitaria*					
SM	SR	SH	LP	spotted sandpiper	*Actitis macularia*					
	SR		LP	upland sandpiper	*Bartramia longicauda*		S		A	
SM	SR		LP	long-billed curlew	*Numenius americanus*	C2	S		A	C
			LP	sanderling	*Calidris alba*					
			LP	semipalmated sandpiper	*Calidris pusilla*					
		SH	LP	western sandpiper	*Calidris mauri*					
			LP	least sandpiper	*Calidris minutilla*					
SM	SR	SH	LP	Wilson's phalarope	*Phalaropus tricolor*					
SM	SR	SH	LP	common snipe	*Gallinago gallinago*					
				Laridae						
SM	SR		LP	ring-billed gull	*Larus delawarensis*					
SM	SR	SH	LP	California gull	*Larus californicus*					
	SR			black tern	*Chlidonias niger*	C2	S			
				Columbidae						
SM	SR	SH	LP	mourning dove	*Zenaida macroura*				B	
		SH	LP	rock dove	*Columba livia*					
				Cuculidae						
SM	SR			black-billed cuckoo	*Coccyzus erythropthalamus*				A	
			LP	yellow-billed cuckoo	*Coccyzus americanus*				A	C

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO	CONS
				Birds						
				Strigidae						
			LP	flammulated owl	*Otus flammeolus*		S		A	
SM	SR	SH	LP	screech owl	*Otus asio*					
SM	SR	SH	LP	great horned owl	*Bubo virginianus*					
SM	SR	SH	LP	burrowing owl	*Athene cunicularia*	C2	S		A	C
SM	SR		LP	long-eared owl	*Asio otus*				B	
SM	SR		LP	short-eared owl	*Asio flammeus*				B	C
SM	SR			boreal owl	*Aegolius funereus*		S			
SM	SR	SH	LP	saw-whet owl	*Aegolius acadicus*					
				Caprimulgidae						
SM	SR	SH	LP	common nighthawk	*Chordeiles minor*				A	
SM	SR	SH	LP	poor-will	*Phalaenoptilus nuttallii*				B	
				Apodidae						
	SR			black swift	*Cypseloides niger*		S		A	
			LP	chimney swift	*Chaetura pelagica*				A	
SM	SR		LP	white-throated swift	*Aeronautes saxatalis*				A	
				Trochilidae						
			LP	black-chinned hummingbird	*Archilochus alexandri*				A	
SM	SR	SH	LP	broad-tailed hummingbird	*Selasphorus platycercus*				A	
SM	SR	SH	LP	rufus hummingbird	*Selasphorus rufus*				A	
				Alcedinidae						
SM	SR	SH	LP	belted kingfisher	*Ceryle alcyon*				B	
				Picidae						
SM	SR	SH	LP	Lewis' woodpecker	*Melanerpes lewis*		S	EC	B	C
			LP	red-headed woodpecker	*Melanerpes erythrocephalus*					
SM	SR	SH	LP	yellow-bellied sapsucker	*Sphyrapicus varius*			EC	B	
	SR	SH	LP	red-naped sapsucker	*Sphyrapicus nuchalis*				B	C
SM	SR	SH	LP	Williamson's sapsucker	*Sphyrapicus thryroideus*				B	C
SM	SR	SH	LP	downy woodpecker	*Picoides pubescens*					
SM	SR	SH	LP	hairy woodpecker	*Picoides pubescens*			EC		
SM	SR	SH	LP	northern three-toed woodpecker	*Picoides tridactylus*		S			
SM	SR	SH	LP	red-shafted flicker	*Colaptes auratus cafer*				B	
				Tyrannidae						
SM	SR	SH	LP	olive-sided flycatcher	*Contopus borealis*	C2	S		A	C
SM	SR	SH	LP	western wood peewee	*Contopus sordidulus*				A	
SM			LP	alder flycatcher	*Empidonax alnorum*				A	
SM	SR	SH	LP	willow flycatcher	*Empidonax traillii*				A	C
			LP	least flycatcher	*Empidonax minimus*				A	C
SM	SR	SH	LP	Hammond's flycatcher	*Empidonax hammondii*				A	C
SM	SR	SH	LP	dusky flycatcher	*Empidonax oberholseri*				A	C
SM	SR	SH	LP	gray flycatcher	*Empidonax wrightii*				A	C
SM	SR	SH	LP	Say's phoebe	*Sayornis saya*				B	
SM	SR	SH	LP	cordilleran flycatcher	*Empidonax difficulis*				A	C
		SH	LP	Cassin's kingbird	*Tyrannus vociferans*				A	
SM	SR	SH	LP	western kingbird	*Tyrannus verticalis*				A	
	SR	SH	LP	eastern kingbird	*Tyrannus tyrannus*				A	
				Alaudidae						
SM	SR	SH	LP	horned lark	*Eremophila alpestris*				B	
				Hirundinidae						
SM	SR	SH	LP	purple martin	*Progne subis*		S		A	
SM	SR	SH	LP	tree swallow	*Tachycineta bicolor*				B	
SM	SR	SH	LP	violet-green swallow	*Tachycineta thalassina*				A	
SM	SR	SH	LP	rough-winged swallow	*Stelgidopteryx serripennis*				A	
SM	SR	SH	LP	bank swallow	*Riparia riparia*				A	
SM	SR	SH	LP	cliff swallow	*Hirundo pyrrhonota*				A	
SM	SR	SH	LP	barn swallow	*Hirundo rustica*				A	

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO	CONS
				Birds						
				Corvidae						
SM	SR	SH	LP	gray jay	*Perisoreus canadensis*					
SM	SR	SH	LP	Steller's jay	*Cyanocitta stelleri*					
SM	SR	SH	LP	blue jay	*Cyanocitta cristata*					
SM	SR	SH	LP	pinyon jay	*Gymnorhinus cyanocephalus*					
SM		SH	LP	scrub jay	*Aphelocoma coerulescens*					
SM	SR	SH	LP	Clark's nutcracker	*Nucifraga columbiana*					
SM	SR	SH	LP	black-billed magpie	*Pica pica*					
SM	SR	SH	LP	American crow	*Corvus brachyrhynchos*					
SM	SR	SH	LP	common raven	*Corvus corax*					
				Paridae						
SM	SR	SH	LP	black-capped chickadee	*Parus atricapillus*					
SM	SR	SH	LP	mountain chickadee	*Parus gambeli*					
			LP	plain titmouse	*Parus inornatus*					
				Sittidae						
SM	SR	SH	LP	red-breasted nuthatch	*Sitta canadensis*					
SM	SR	SH	LP	white-breasted nuthatch	*Sitta carolinensis*					
SM	SR	SM	LP	pygmy nuthatch	*Sitta pygmaea*		S			
				Certhiidae						
SM	SR	SH	LP	brown creeper	*Certhia americana*				B	
				Troglodytidae						
SM	SR	SH	LP	canyon wren	*Catherpes mexicanus*					
SM	SR	SH	LP	rock wren	*Salpinctes obsoletus*				B	
SM	SR		LP	Bewick's wren	*Thryomanes bewickii*					
SM	SR	SH	LP	house wren	*Troglodytes aedon*				A	
		SH	LP	winter wren	*Troglodytes troglodytes*					
			LP	short-billed marsh wren	*Cistothorus platensis*				B	
SM	SR			long-billed marsh wren	*Cistothorus palustris*				B	C
				Cinclidae						
SM	SR	SH	LP	dipper	*Cinclus mexicanus*					
				Muscicapidae						
SM	SR	SH	LP	golden-crowned kinglet	*Regulus satrapa*		S			
SM	SR	SH	LP	ruby-crowned kinglet	*Regulus calendula*			EC	B	
SM	SR			blue-grey gnatcatcher	*Polioptila caerulea*				A	
SM	SR	SH	LP	western bluebird	*Sialia mexicana*				B	
SM	SR	SH	LP	mountain bluebird	*Sialia curricoides*				B	
SM	SR	SH	LP	Townsend's solitaire	*Myadestes townsendi*				B	
SM	SR	SH	LP	veery	*Catharus fuscescens*				A	
SM	SR	SH	LP	Swainson's thrush	*Catharus ustulatus*				A	
SM	SR	SH	LP	hermit thrush	*Catharus guttatus*				B	
SM	SR	SH	LP	American robin	*Turdus migratorius*				B	
				Mimidae						
SM	SR	SH	LP	gray catbird	*Dumetella carolinensis*				A	
SM		SH	LP	northern mockingbird	*Mimus polyglottos*					
SM	SR	SH	LP	brown thrasher	*Toxostoma rufum*					
SM	SR	SH	LP	sage thrasher	*Oreoscoptes montanus*				B	C
				Bombycillidae						
			LP	Bohemian waxwing	*Bombycilla garrulus*					
SM	SR	SH	LP	cedar waxwing	*Bombycilla cedrorum*			EC	B	
				Motacillidae						
SM	SR		LP	water pipit	*Anthus spinoletta*				B	
				Laniidae						
SM	SR	SH	LP	northern shrike	*Lanius excubitor*					
SM	SR	SH	LP	loggerhead shrike	*Lanius ludovicianus*	C2	S		B	C
				Sturnidae						
SM	SR	SH	LP	starling	*Sturnus vulgaris*					

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO	CONS
				Birds						
				Vireonidae						
SM	SR	SH	LP	solitary vireo	*Vireo solitarius*				A	C
SM	SR	SH	LP	warbling vireo	*Vireo gilvus*				A	C
SM	SR	SH	LP	red-eyed vireo	*Vireo olivaceus*				A	
				Emberizidae						
SM	SR	SH	LP	orange-crowned warbler	*Vermivora celata*				A	
			LP	Virginia's warbler	*Vermivora virginiae*				A	
SM	SR	SH	LP	yellow warbler	*Dendroica petechia*			EC	A	C
		SH	LP	magnolia warbler	*Dendroica magnolia*				A	
SM	SR	SH	LP	yellow-rumped warbler	*Dendroica coronata*				B	
SM	SR	SH	LP	Townsend's warbler	*Dendroica townsendi*				A	
			LP	pine warbler	*Dendroica pinus*					
			LP	blackpoll warbler	*Dendroica striata*				A	
			LP	black-and-white warbler	*Mniotilta varia*				A	
SM	SR		LP	American redstart	*Setophaga ruticilla*				A	
SM	SR	SH	LP	ovenbird	*Seiurus aurocapillus*				A	C
SM	SR	SH	LP	MacGillivary's warbler	*Oporornis tolmiei*				A	C
SM	SR	SH	LP	common yellowthroat	*Geothlypis trichas*				A	C
SM	SR	SH	LP	Wilson's warbler	*Wilsonia pusilla*				A	
SM	SR	SH	LP	yellow-breasted chat	*Icteria virens*				A	
SM	SR	SH	LP	western tanager	*Piranga ludoviciana*				A	
SM	SR	SH	LP	black-headed grosbeak	*Pheucticus melanocephalus*				A	
SM	SR	SH	LP	Lazuli bunting	*Passerina amoena*				A	
SM	SR	SH	LP	green-tailed towhee	*Pipilo chlorura*				A	C
SM	SR	SH	LP	rufous-sided towhee	*Pipilo erythrophthalmus*				B	
SM	SR	SH	LP	tree sparrow	*Spizzella arborea*					
SM	SR	SH	LP	chipping sparrow	*Spizzella passerina*				A	
SM	SR	SH	LP	clay-colored sparrow	*Spizzella pallida*				A	C
SM	SR		LP	Brewer's sparrow	*Spizzella breweri*				A	
SM	SR			sage sparrow	*Amphispiza belli*				B	C
SM	SR	SH	LP	vesper sparrow	*Pooecetes gramineus*				B	
SM	SR	SH	LP	lark sparrow	*Chondestes grammacus*				A	
SM	SR	SH	LP	lark bunting	*Calamospiza melanocorys*				A	C
			LP	Baird's sparrow	*Ammodramus bairdii*	C2				
SM	SR	SH		fox sparrow	*Pasarella iliaca*		S		B	
SM	SR	SH	LP	Lincoln's sparrow	*Melospiza lincolnnii*				A	
SM	SR	SH	LP	song sparrow	*Melospiza melodia*				B	
SM	SR	SH	LP	Harris' sparrow	*Zonotrichia querula*					
SM	SR	SH	LP	dark-eyed junco	*Junco hyemalis*				B	
SM	SR	SH	LP	white-crowned sparrow	*Zonotrichis leucophrys*			EC	B	
SM	SR	SH	LP	white-throated sparrow	*Zonotrichis albicaulis*					
SM	SR	SH	LP	McCown's longspur	*Calcarius mccownii*				B	C
SM	SR	SH	LP	red-winged blackbird	*Agelaius phoeniceus*				B	
SM	SR	SH	LP	western meadowlark	*Sturnella neglecta*				B	
SM	SR			yellow-headed blackbird	*Xanthocephalus xanthocephalus*				A	C
SM	SR	SH	LP	Brewer's blackbird	*Euphagus cyanocephalus*				B	
	SR		LP	common grackle	*Quiscalus quiscula*					
SM	SR	SH	LP	brown-headed cowbird	*Molothrus ater*				B	
SM	SR		LP	northern oriole	*Icterus galbula*				A	
SM	SR		LP	Bullock's oriole	*Icterus bullockii*					

SM	SR	SH	LP	COMMON NAME & FAMILY	*SCIENTIFIC NAME*	TEC	SEN	MIS	NEO	CONS
				Birds						
				Fringillidae						
SM	SR	SH	LP	evening grosbeak	*Coccothraustes vespertinus*					
SM	SR	SH	LP	Cassin's finch	*Carpodacus cassinii*					B
SM	SR	SH	LP	house finch	*Carpodacus mexicanus*					
SM	SR	SH	LP	pine grosbeak	*Pinicola enucleator*					
SM	SR		LP	rosy finch	*Leucosticte arctoa*					
SM	SR	SH	LP	pine siskin	*Carduelis pinus*					B
SM	SR	SH	LP	red crossbill	*Loxia curvirostra*					
SM	SR	SH	LP	American goldfinch	*Carduelis tristis*					B
				Ploceidae						
SM	SR	SH	LP	house sparrow	*Passer domesticus*					

APPENDIX 10

NEOTROPICAL MIGRATORY BIRDS

by Sally Tinker

DECLINES IN NEOTROPICAL MIGRATORY BIRD POPULATIONS

Declines in populations of about 250 species of NTMB in North America are attributed to both fragmentation of North American breeding habitats and to loss of Southern habitats resulting from the deforestation of avian wintering grounds (Finch 1991b, Finch and Stangle 1992; Robertson 1991; Mauer 1992; Manley et al. 1993).

From 1978 to 1987, as deforestation increasingly consumed tropical forests, national Breeding Bird Surveys noted population declines in seventy-five percent of neotropical forest species (Finch, 1991b). Fragmentation of northern habitats, in conjunction with the widespread use of herbicides and pesticides, intrusive recreational activities, and various other land use activities, has also contributed to precipitous declines in migrating neotropical species. North America has experienced increasing forest fragmentation due to clear cut logging practices, urban development, agricultural development, road and power line construction, water reservoir creation, and surface mining. Many migrating neotropical species depend on extensive unbroken tracts of forest; fragmentation of these large tracks can lead to species declines or local extinctions (Finch and Ruggiero 1993).

NEOTROPICAL MIGRATORY BIRD CONSERVATION PROGRAMS

In July 1990, the National Fish and Wildlife Foundation founded the Neotropical Migratory Bird Conservation Program (NTMB), initiating national and international efforts for monitoring and conservation of neotropical migrants. The program investigates the temporal dynamics and population trends for various avian species through extensive national and international monitoring (Manley et al. 1993). Information on population dynamics helps assess avian population viabilities over time (Manley et al. 1993).

In their 1990 Atlantic report, the NTMB Program, also known as "Partners in Flight - *Aves de las Americas*", expressed goals to "generate, synthesize, and communicate the information necessary to identify and implement the appropriate conservation and management measures for the maintenance of healthy populations of neotropical migrating birds, including the recovery of declining species" (Finch 1991b).

Partners in Flight outlined the need to develop a better understanding of the consequences of changes to neotropical migrant habitats resulting from National Forest Service management activities. In addition, they placed a strong emphasis on the importance of monitoring and avian conservation on land within the National Forest Service System, as many species of migrants breed and nest on these lands.

In 1991, U.S. National Forest Service Chief F. Dale Robertson signed a Memorandum of Agreement, creating an interagency committee designed to identify the actions necessary for the conservation of neotropical migrants (Robertson 1991). The committee, which included representatives from the U.S. Fish and Wildlife Service, the National Park Service, the Bureau of Land Management, the Environmental Protection Agency, the U.S. Agency for International Development, and the Department of the Navy, supported programs of research, monitoring, and applied management (Finch 1991b, Robertson 1991).

Assisting the Federal Agencies efforts were numerous non-governmental agencies, including the National Fish and Wildlife Association, the Smithsonian Institute, the American Forest Resource Alliance, the International Association of Fish and Wildlife Agencies, the Conservation International Association, the International Council for Bird Preservation, the Point Reyes and Monoment Bird Observatories, the Cornell Laboratory of Ornithology, and the National Audubon Society (Finch 1991a).

BIRD HABITAT RESEARCH ON THE MBNF

The Medicine Bow National Forest (MBNF) has hosted a number of avian research projects, by Forest Service employees, students and faculty affiliated with the University of Wyoming, and other researchers. NTMB species and habitats are included in most of these studies. Avian research done specifically on the MBNF are marked with a * in the References Cited and Additional References sections of this Appendix.

Pioneering studies conducted on the MBNF include a number of projects done by Deborah Finch and Richard Reynods (formerly of Rocky Mountain Research and Experimental Station, Laramie Unit) on neotropical migrants, riparian bird species, bird-habitat relationships, and other pertinent avian projects. In 1986 research wildlife biologist Finch investigated the similarities in riparian bird communities among elevational zones in the MBNF, examining avian species richness and abundance in riparian habitats for elevations from 6740 feet to 9800 feet (Finch 1986). Finch's research revealed lower avian species richness at higher elevations,

due in part to restrictive environmental conditions and reduced habitat diversity (Finch 1986).

Finch noted that "if a riparian ecosystem appears healthy that best management approach is that of protection rather than alteration". She suggested some management practices which might yield increased density and diversity for avian species in riparian areas (Finch 1986): Management techniques could manipulate lower riparian shrub density and structure through grazing, might attempt to introduce native shrub species, and revegetate sites which have lost significant amounts of aspen or cottonwood overstory. Habitat in treeless riparian areas could be supplemented by providing nest boxes on large shrubs or nest platforms. Increased numbers of of beaver dams would generally benefit NTMB because beaver ponds tend to widen and deepen the flood plain, providing more moisture and nutrients for the flora.

Bird responses to understory variation and conifer succession in aspen forests on the MBNF were investigated by researchers from the Rocky Mountain Station in 1987. They identified and evaluated relationships of aspen habitats and avian species, concentrating on the effects of timber harvesting and fragmentation They found that "clearcutting may improve some aspen subtypes by creating a mosaic of different structural stages attractive to different bird species, but may degrade other subtypes by removing or decreasing key habitat components necessary for survival or breeding of sensitive species" Finch and Reynolds 1987)

Finch and Reynolds conducted additional studies in the MBNF examining bird-habitat relationships in subalpine riparian shrublands. They found avian preferences for densely-foliated ground and shrub layers andthat various avian species respond in differing manners to habitat variation, making it difficult to design or implement any management scheme that could address the needs of all avian species. They stated that management "can enhance riparian habitats by managing for higher shrub density, greater canopy cover, and greater shrub size, and enhance shrub and surface cover and ground vegetative diversity" (Finch and Reynolds 1987).

In 1989 a series of studies in the MBNF focusing on habitat use and habitat overlap of breeding riparian birds in three elevational zones was begun (Finch 1989a). Positive associations among riparian bird species corresponded to elevational changes in plant communities (Finch 1989b), and species abundances, guild dominance patterns, and community structure of breeding riparian birds (Finch 1989c). Finch noted that "numerical changes in bird populations at the group or guild level explain overall changes in species richness and bird abundance along habitat gradients" (Finch 1989b). Finch found that species diversity in a habitat is related

to resource variety and abundance within a habitat, thus complex habitats, such as lowland riparian habitats, generally support more avian species than less structurally complex habitats, such as higher elevational riparian habitats (Finch 1989a). Finch detected an inverse relationship between species richness and elevation, claiming that "as elevation increases, tree density, shrub height, number of vegetative layers, and foliage density decrease, thus species richness declines with elevational increases" (Finch, 1989c).

Finch concluded that avian density and diversity levels are greater in riparian communities than in upland or temperate terrestrial communities. Thus, for bird conservation, protection of susceptible riparian habitats from potentially threatening activities such as mining, livestock grazing, irrigation, and extensive, varied recreational activities is a management concern (Finch 1989c).

In 1993, Ricard Hutto in a collaborative effort with Sallie Hejl, Charles Preston, and Deborah Finch, addressed the effects of silvicultural treatments on forest birds in the MBNF, outlining specific implications and management recommendations (Hutto, et al. 1993). The group felt that while it appeared apparent that clearcuts adversely effect interior dwelling birds, while favoring those avian species who prefer open habitats, additional effects of timber harvesting remain uncertain (Hutto et al. 1993). Hutto and associates recognized the need to further examination of the long-term effects of timber harvesting, and emphasized the value of establishing the historical range of natural variability with the forest (Hutto et al. 1993).

While the group believed that human activities could mimic, but never replace, natural disturbances, they hoped that after determining the natural range of variability, managers might then initiate management practices which would create landscapes resembling those landscapes produced by natural processes (Hutto et al. 1993). They recommended six specific management approaches; 1) manage for desired landscape patterns 2) manage for the maintenance of natural disturbance regimes 3) use knowledge of the local ecology 4) move toward multi-species management 5) use single-species management only when necessary 6) and monitor both landscape patterns and species populations (Hutto et al. 1993).

Numerous university students and faculty have conducted an array of research projects on the MBNF lands, addressing various topics. In 1985, Henry Krueger, University of Wyoming graduate student, investigated avian responses to mountainous shrub-willow riparian systems in the MBNF (Krueger 1985), and, along with Dr. Stan Anderson, Professor of Zoology, University of Wyoming,

studied the use of cattle as a management tool for wildlife in shrub-willow riparian systems (Krueger et al. 1985). Krueger and Anderson noted that cattle can have a beneficial effect on avian communities by carving out vegetative tunnels, inferring that "cattle can be used as a management tool to benefit small mammal and bird communities by creating tunnels in dense vegetation", but warned that "managers must be able to control the distribution of cattle in allotments to prevent the detrimental effects of grazing" (Krueger 1985; Krueger and Anderson 1985).

In 1986, University of Wyoming graduate student Catherine Raley studied the availability and use of invertebrate food resources by high elevational riparian birds in the MBNF (Raley 1986). Raley's research indicated that birds seem attracted to riparian willow areas because of the presence and abundance of food resources, rather than because of the vegetation present (Raley 1986). Raley recognized the need for suitable vegetation, adequate soil moisture, and available water sources in riparian habitats for viable avian food sources. Loss of willow habitat, or invasive management practices which resulted in the reduction or depletion of avian food resources, would probably result in declines or local extinctions of Wilson's warblers, Lincoln's sparrows, and other neotropical migrants who utilize riparian habitats (Raley 1986).

Other research performed by individuals affiliated with the University of Wyoming in Laramie, includes work done in 1980 by professors Kenneth Diem and Samuel Zevloff on ponderosa pine bird communities in the MBNF (Diem and Zevloff 1980). They studied bird species composition and distribution within biologically diverse ponderosa pine habitats, and recounted the need for sagacious management to ensure the continuance of critical avian habitat (Diem et al. 1980)

In 1991, working through the University of Wyoming's Cooperative Wildlife and Fisheries Research Unit, Mary Keller and Stan Anderson on explored avian use of habitat configurations created by forest cutting in the MBNF. Their work revealed that the fragmentation of forests through strip and spot cuts results in a loss or reduction of resources and an increase in the edge to interior ratios, which tends to detrimentally impact interior dwelling species such as the brown creeper and hermit thrush. Keller and Anderson stated that "the most important effect of the early stages of fragmentation by clearcutting is the absolute loss of habitat and reduced density of associated resources", noting that "resources must occur in sufficient density within a defendable area to permit species to occur in a stand" (Keller and Anderson 1992).

NTMB BIRD-HABITAT RELATIONSHIPS

One hundred and twenty-one neotropical migrants spend a portion of the year breeding, foraging, and nesting in portions of the MBNF (Table 8.9 CHAPTER 8). A variety of habitats are used during migration and during the breeding season (Table 8.10 for selected NTMB species of concern based on ratings of "4" or "5" for overall abundance or threats to breeding ground). Of the habitats used by NTMB on the MBNF, riparian ecosystems and old-growth forests appear to be most affected by management activities.

CONIFEROUS FOREST HABITATS

Old Growth-Mixed Conifer Habitat

Old growth forest provides sanctuary for a variety of aviflora and fauna (Kaufman et al. 1992), harboring many specialist species, such as bald eagles, Hammond's flycatchers, pine grosbeaks, and Townsend's warblers (Meslow et al. 1981). Certain neotropical migrants, such as the flammulated owl, seem to prefer old growth habitats above all other habitats, (Romme et al. 1992).

Although cavity dwellers reside in a variety of habitats, many cavity nesting birds seem to prefer and thrive in old growth forests, as old forests typically contain higher numbers of old snags and large dead-standing trees (Romme et al. 1992). Some species, such as the northern goshawk require large, live trees for nesting, such as those found in old growth forest patches (Crocker-Bedford 1990). In southwestern Colorado, research revealed that northern goshawks preferred trees at least 25 cm in diameter, or larger for nesting (Shuster 1980).

Fifty-six different avian migrant have been observed in spruce-fir forests (Ryder 1978). On the MBNF, coniferous forest species include the northern goshawk, sharp-shinned hawk, olive-sided flycatcher, ovenbird, Hammond's flycatcher, sharp-shinned hawk, Cooper's hawk, peregrine falcon, cordilleran flycatcher, dusky flycatcher, solitary vireo, warbling vireo, yellow warbler, MacGillvary's warbler, common yellowthroat, Lewis' woodpecker, turkey vulture, red-tailed hawk, peregrine falcon, merlin, American kestrel, bald eagle, flammulated owl, black swift, broad-tailed hummingbird, rufous hummingbird, yellowbellied sapsucker, Williamson's sapsucker, Cassin's kingbird, eastern kingbird, western kingbird, violet-green swallow, tree swallow, rough-winged swallow, brown creeper, house wren, American robin, Swainson's thrush, hermit thrush, veery, mountain bluebird, Townsend's solitaire, ruby-crowned kinglet, warbling vireo, white-crowned sparrow, Lincoln's sparrow, song sparrow, pine siskin, Cassin's finch, dark-eyed junco, lark

sparrow, vesper sparrow, yellow-rumped warbler, western meadowlark, and Brewer's blackbird.

Lodgepole Pine Habitat

There seems to exist an apparent need for further research on avian interactions with lodgepole pine habitats. While few studies have been conducted on the avifauna in lodgepole pine patches, the research available suggests that no avian species is restricted solely to lodgepole pine forests, and that no endangered species rely primarily on lodgepole pine habitats (Hein 1980). However, at least fifty-three migratory species make use of lodgepole forests (Ryder 1978). See Table 8.10 for species which are known to utilize lodgepole pine forests on the Medicine Bow National Forest. These pecies include the northern goshawk, sharp-shinned hawk, olive-sided flycatcher, ovenbird, Hammond's flycatcher, sharp-shinned hawk, Cooper's hawk, peregrine falcon, cordilleran flycatcher, dusky flycatcher, solitary vireo, warbling vireo, yellow warbler, MacGillvary's warbler, common yellowthroat, turkey vulture, red-tailed hawk, peregrine falcon, merlin, American kestrel, black swift, broad-tailed hummingbird, rufous hummingbird, mourning dove, yellowbellied sapsucker, Williamson's sapsucker, western wood peewee, violet-green swallow, tree swallow, brown creeper, house wren, American robin, Swainson's thrush, hermit thrush, veery, mountain bluebird, Townsend's solitaire, ruby-crowned kinglet, warbling vireo, white-crowned sparrow, fox sparrow, Lincoln's sparrow, song sparrow, pine siskin, Cassin's finch, dark-eyed junco, lark sparrow, vesper sparrow, yellow-rumped warbler, western meadowlark, western tananger, and Brewer's blackbird.

Ponderosa Pine Habitat

Ponderosa pine forest provides habitat for a great diversity of birds because of insect food supplies, small mammals in nearby shrublands and grasslands, lower elevation range and associated riparian habitat. Over a hundred different species of avian migrants utilize ponderosa forests (Ryder 1978; Finch and Reynolds 1993). Ponderosa pine habitats in the MBNF can host such species as the northern goshawk, sharp-shinned hawk, olive-sided flycatcher, ovenbird, Hammond's flycatcher, sharp-shinned hawk, Cooper's hawk, peregrine falcon, cordilleran flycatcher, dusky flycatcher, solitary vireo, warbling vireo, yellow warbler, MacGillvary's warbler, common yellowthroat, Lewis' woodpecker, prairie falcon, short-eared owl, loggerhead shrike, green-tailed towhee, gray flycatcher, least fly catcher, willow flycatcher, turkey vulture, Swainson's hawk, red-tailed hawk, ferruginous hawk, golden eagle, peregrine falcon, killdeer, merlin, American kestrel, flammulated owl, burrowing owl, short-eared owl, long-eared owl, poor-will, common nighthawk, white-

throated swift, broad-tailed hummingbird, rufous hummingbird, mourning dove, yellowbellied sapsucker, Williamson's sapsucker, western wood peewee, Cassin's kingbird, eastern kingbird, western kingbird, Say's phoebe, willow flycatcher, least flycatcher, horned lark, violet-green swallow, tree swallow, rough-winged swallow, bank swallow, barn swallow, cliff swallow, purple martin, brown creeper, house wren, rock wren, American robin, Swainson's thrush, hermit thrush, veery, western bluebird, mountain bluebird, Townsend's solitaire, ruby-crowned kinglet, water pipit, cedar waxwing, warbling vireo, black-and-white warbler, orange-crowned warbler, magnolia warbler, white-crowned sparrow, fox sparrow, fox sparrow, Lincoln's sparrow, song sparrow, pine siskin, black-headed grosbeak, American goldfinch, lazuli bunting, Cassin's finch, rufous-sided towhee, dark-eyed junco, lark sparrow, vesper sparrow, yellow-rumped warbler, western meadowlark, western tananger, American redstart, yellow-headed blackbird, northern oriole, red-winged blackbird, brown-headed cowbird, Townsend's warbler, blackpoll warbler, yellow-breasted chat, Wilson's warbler, gray catbird, Brewer's sparrow, and Brewer's blackbird.

OTHER FORESTED HABITATS

Aspen Habitat

Aspen groves contain a high density and diversity of avian species (Finch and Reynolds 1987; Scott and Crouch 1988a, 1988b; Finch and Ruggiero 1993), possibly due to the geographic, structural, and floristic variations, and high density and diversity of insects, found in aspen groves (Finch et al. 1993). Studies in western Wyoming revealed that avian biomass in aspen patches was three times greater than bird mass in other habitat types (Salt 1957; Finch et al. 1993). Many cavity nesting neotropical species, such as the purple martin, breed and nest in aspen groves (Finch et al. 1993). A scarcity or lack of appropriate roost and nest sites can negatively limit the number and abundance of avian cavity dwellers (Beebe 1974), thus a reduction of aspen habitat embedded with other forest types may alter the composition and density of avian species. Declines in cavity dwelling species may result in an increased numbers of insects and more insect epidemics, as most cavity dwellers are insectivorous, and their insect consumption may contribute to insect control within a forest (Beebe 1974; Scott and Svoboda 1980).

Over sixty avian species breed, nest, or forage in aspen groves (Ryder 1978) in the MBNF. NTMB species include the northern goshawk, Williamson's sapsucker, olive-sided flycatcher, ovenbird, sharp-shinned hawk, Cooper's hawk, peregrine falcon, cordilleran flycatcher, solitary vireo, warbling vireo, yellow warbler, MacGillvary's warbler, common yellowthroat, Lewis' woodpecker,

prairie falcon, short-eared owl, loggerhead shrike, green-tailed towhee, willow flycatcher, turkey vulture, red-tailed hawk, merlin, American kestrel, flammulated owl, black swift, broad-tailed hummingbird, rufous hummingbird, yellowbellied sapsucker, western wood peewee, western kingbird, Say's phoebe, willow flycatcher, Hammond's flycatcher, dusky flycatcher, violet-green swallow, tree swallow, house wren, American robin, Swainson's thrush, hermit thrush, western bluebird, mountain bluebird, Townsend's solitaire, ruby-crowned kinglet, warbling vireo, white-crowned sparrow, fox sparrow, fox sparrow, Lincoln's sparrow, song sparrow, pine siskin, dark-eyed junco, lark sparrow, vesper sparrow, yellow-rumped warbler, western meadowlark, western tananger, red-winged blackbird, brown-headed cowbird, and Townsend's warbler.

SHRUBLAND HABITATS

In the MBNF, over ninety-one NTMB migrants utilize shrubland habitats for foraging, breeding, and nesting (Ryder, 1978). Species found in the shrublands include the sharp-shinned hawk, Cooper's hawk, peregrine falcon, cordilleran flycatcher, dusky flycatcher, solitary vireo, warbling vireo, yellow warbler, MacGillvary's warbler, common yellowthroat, prairie falcon, short-eared owl, long-eared owl, loggerhead shrike, green-tailed towhee, gray flycatcher, yellow-headed blackbird, northern harrier, long-billed curlew, yellow-billed cuckoo, black-billed cuckoo, turkey vulture, red-tailed hawk, ferruginous hawk, merlin, American kestrel, killdeer, burrowing owl, poor-will, common nighthawk, chimney swift, white-throated swift, rufous hummingbird, mourning dove, yellowbellied sapsucker, western wood peewee, Cassin's kingbird, eastern kingbird, western kingbird, Say's phoebe, willow flycatcher, least flycatcher, gray flycatcher, horned lark, tree swallow, rough-winged swallow, bank swallow, barn swallow, cliff swallow, purple martin, brown creeper, house wren, short-billed marsh wren, long-billed marsh wren, rock wren, American robin, Swainson's thrush, mountain bluebird, blue-gray gnatcatcher, water pipit, cedar waxwing, warbling vireo, black-and-white warbler, orange-crowned warbler, Virginia's warbler, magnolia warbler, white-crowned sparrow, Lincoln's sparrow, song sparrow, pine siskin, black-headed grosbeak, American goldfinch, lazuli bunting, Cassin's finch, rufous-sided towhee, dark-eyed junco, lark sparrow, vesper sparrow, yellow-rumped warbler, western meadowlark, western tananger, American redstart, yellow-headed blackbird, northern oriole, red-winged blackbird, brown-headed cowbird, Townsend's warbler, blackpoll warbler, yellow-breasted chat, Wilson's warbler, gray catbird, Brewer's sparrow, and Brewer's blackbird.

GRASSLAND HABITATS

Grasslands furnish crucial habitat for many bird species (Finch and Ruggiero 1993). The grasslands along the edges of the MBNF provide habitat for over eighty-six NTMB migrants (Ryder 1978) including the least flycatcher, clay-colored sparrow, burrowing owl, ferruginous hawk, lark bunting, yellow-headed blackbird, northern harrier, yellow-billed cuckoo, sharp-shinned hawk, McCown's longspur, turkey vulture, Cooper's hawk, red-tailed hawk, Swainson's hawk, golden eagle, peregrine falcon, killdeer, merlin, American kestrel, long-billed curlew, upland sandpiper, black-billed cuckoo, short-eared owl, long-eared owl, common nighthawk, chimney swift, white-throated swift, mourning dove, yellowbellied sapsucker, western wood peewee, eastern kingbird, western kingbird, Say's phoebe, willow flycatcher, tree swallow, rough-winged swallow, bank swallow, barn swallow, cliff swallow, purple martin, brown creeper, house wren, short-billed marsh wren, long-billed marsh wren, rock wren, American robin, Swainson's thrush, veery, mountain bluebird, water pipit, cedar waxwing, warbling vireo, black-and-white warbler, orange-crowned warbler, magnolia warbler, white-crowned sparrow, fox sparrow, Lincoln's sparrow, song sparrow, pine siskin, black-headed grosbeak, American goldfinch, lazuli bunting, Cassin's finch, dark-eyed junco, lark sparrow, vesper sparrow, yellow-rumped warbler, western meadowlark, western tananger, American redstart, yellow-headed blackbird, northern oriole, red-winged blackbird, brown-headed cowbird, Townsend's warbler, blackpoll warbler, yellow-breasted chat, Wilson's warbler, gray catbird, Brewer's sparrow, and Brewer's blackbird.

RIPARIAN HABITATS

Riparian areas, including wetlands, marshes, bogs, shallow ponds, and kettleholes, along with the woodlands and shrublands that border streams, rivers and lakes, form some of the most important avian habitat in the forest, even though these areas constitute only a small portion of the Rocky Mountain region (Ryder 1978; Finch, 1989a; Schulz and Leininger 1991; Finch and Ruggiero 1993). Riparian areas serve as migration corridors, offer necessary stop-over sites for migrants, furnish breeding habitat for numerous species, and provide feeding grounds for various aquatic-feeding birds (Raley 1986; Finch and Ruggiero 1993). Riparian habitats tend to exhibit higher avian species densities, and diversities compared to upland or terrestrial habitats (Finch 1989c; Bock et al. 1993; Finch et al.; 1993). Numerous threatened, endangered, former candidate and sensitive (TECS) species utilize riparian areas, including eagles, whooping cranes, piping plovers, snowy plovers, long-billed curlews, and white-faced ibis (Finch et al. 1993) NTMB specie such as Wilson's warbler and Lincoln's sparrow, utilize

willow thickets for lookout perches and song posts, as well as breeding, nesting, and foraging grounds (Raley 1986).

At least fifty-two migratory species make use of riparian habitats (Ryder 1978). Riparian areas in the MBNF entertain the willow flycatcher, sharp-shinned hawk, McCown's longspur, yellow-headed blackbird, northern harrier, long-billed curlew, black-billed cuckoo, yellow-billed cuckoo, long-billed marsh wren, sage thrasher, red-naped sapsucker, sage sparrow, turkey vulture, red-tailed hawk, merlin, American kestrel, Williamson's sapsucker, yellow-bellied sapsucker, eastern kingbird, willow flycatcher, horned lark, bank swallow, brown creeper, house wren, short-billed marsh wren, veery, ruby-crowned kinglet, water pipit, cedar waxwing, warbling vireo, black-and-white warbler, orange-crowned warbler, Virginia's warbler, magnolia warbler, white-crowned sparrow, fox sparrow, Lincoln's sparrow, song sparrow, black-headed grosbeak, American goldfinch, lazuli bunting, rufous-sided towhee, western tananger, American redstart, yellow-headed blackbird, northern oriole, red-winged blackbird, brown-headed cowbird, blackpoll warbler, yellow-breasted chat, Wilson's warbler, and Brewer's blackbird.

LITERATURE CITED - NEOTROPICAL MIGRATORY BIRDS

* refers to studies conducted on the Medicine Bow National Forest

Beebe, S.B. 1974. Relationships btween isectivorous hole-nesting birds and forest management. Graduate Thesis, Yale University of Forestry and Environmental Studies.

Bock, C.E.; Saab, V.A.; Rich, T.D.; Dobkin, D.S. 1993. Effects of Livestock grazing on Neotropical Migratory Landbirds in Western North America. Gen Tech Rep RM-229. U.S. Department of Agriculture, Forest Service. Fort Collions, CO.

Crocker-Bedford, D.C. 1990. Goshawk reproduction and forest mangement. Wildlife Society Bulletin **18**: 262-269.

*Diem, K.L; Zevloff, S. 1980. Ponderosa pine bird communities. IN: Workshop for Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Feb. 11-14, 1980. U.S. Department of Agriculture, Forest Service, Gen Tech Rep INT-86, Rocky Mountain Forest and Range Experimental Station, Ogden, UT.

*Finch, D.M. 1986. Similarities in riparian bird communities among elevational zones in Southeastern Wyoming. Proceedings Wyoming 1986 Water and Streamside Zone Conference, Casper, WY, Apr. 28-30, 1986.

*Finch, D.M. 1987. Bird-habitat relationships in subalpine riparian shrublands of the central Rocky Mountains. Gen Tech Rep RM-149. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. Fort Collins, CO.

*Finch, D.M. 1989a. Habitat use and habitat overlap of riparian birds in three elevational zones. Ecology **70**: 866-880.

*Finch, D.M. 1989b. Positive associations among riparian bird species correspond to elevational changes in plant communities. Canadian Journal of Zoology **69**: 951-963.

*Finch, D.M. 1989c. Species abundances, guild dominance patterns, and community structure of breeding riparian birds, IN: Freshwater Wetlands and Wildlife, 1989, CONF-8603101, DOE Symposium Series No. 61, Sharitz, R.R. and J.W. Gibbons eds., USDOE Office of Scientific and Technical Information, Oak Ridge, TN.

Finch, D.M. 1991a. Neotropical migratory bird research at the Rocky Mountain Forest and Range Experimental Station. U.S. Department

of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. Fort Collins, CO.

Finch, D.M. 1991b. Population ecology, habitat requirements, and conservation of Neotropical Migratory Birds. Gen Tech Rep RM-205. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. Fort Collins, CO.

Finch, D.M. 1993. Opportunities and goals of the Neotropical Migratory Bird Conservation Program - Partners in Flight. Proceedings of workshop, Prince Albert, Saskatchewan, Mar. 10-12, 1992.

Finch, D.M.; Block, W.M.; Fletcher, R.A.; Fager, L.F. 1993. Integrating Neotropical Migratory Birds into Forest Service Plans for Ecosystem Management. Trans. 58th Wildlife and Natural Resources Conference, 417-421.

*Finch, D.M.; Reynolds, R.T. 1987. Bird response to understory variations in conifer succession in aspen forests. In: J. Emerick; S.Q. Foster; L. Hayden-Wing; J. Hodgson; J.W. Monarch; A. Smith II; O. Thorne and J. Todd (Eds.) Issues and Technology in the Management of Impacted Wildlife; Proc. of a National Symposium; Colorado Springs, CO, Nov. 2-4, 1987. Boulder, Thorne Ecological Institute: 87-96.

*Finch, D.M.; Ruggiero, L.F. 1993. Wildlife habitats and biological diversity in the Rocky Mountains and Northern Great Plains. Natural Areas Journal 13: 191-203.

Hein, D. 1980. Management of lodgepole pine for birds. IN: Workshop for Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Feb. 11-14, 1980. U.S. Department of Agriculture, Forest Service, Gen Tech Rep INT-86, Rocky Mountain Forest and Range Experimental Station, Ogden, UT.

Hutto, R.L.; Hejl, S.J.; Preston, C.R.; Finch, D.M. 1993. Effects of silvicultural treatments on forest birds in the Rocky Mountains: Implications and Management Recommendations. Gen Tech Rep RM-229. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Kaufman, M.R.; Moir, W.H.; Covington, W.W. 1992. Old-growth forests: What do we know about their ecology and management in the Southwest and Rocky Mountain Regions? In: Old-Growth Forests in the Southwest and Rocky Mountain Regions - Proceedings of a Workshop. March 9-13, Portal, Arizona. U.S. Department of Agriculture, Forest Service, Gen Tech Rep RM-213, Rocky Mountain

Forest and Range Experimental Station, Fort Collins, Colo., 1-11.

*Keller, M.E.; Anderson, S.H., 1992. Avian use of habitat configurations created by forest cutting in Southeastern Wyoming. The Condor **94**: 55-65.

*Krueger, H.O. 1985. Avian response to mountainous shrub-willow riparian systems in Southeastern Wyoming. Doctoral Thesis, University of Wyoming, Laramie, WY.

*Krueger, H.O.; Anderson, S.H. 1985. The use of cattle as a management tool for wildlife in shrub-willow riparian systems. Paper presented at symposium on riparian ecosystems and their management: Reconciling conflicting uses, Tucson, AR, Apr. 16-18, 1985.

Manley, P.N.; Block, W.M.; Thompson, F.R.; Butcher, G.S.; Paige, C; Suring, L.H.; Winn, D.S.; Routh, D.; Ralph, C.J.; Morris, E.; Flather, C.H.; Byford, K. 1993 . Guidelines for monitoring populations of Neotropical Migratory Birds on National Forest System lands. Monitoring Task Group Report. U.S Department of Agriculture, Forest Service, Washington, D.C.

Mauer, B.A., Heywood, S.G. 1992. Geographic range fragmentation and abundance in Neotropical Migratory Birds. Conservation Biology 7: 501-509.

Meslow, E.C.; Maser, C.; Verner, J. 1981. Old-growth forests as wildlife habitat. IN: Forty-sixth North American Wildlife Conference. U.S Department of Agriculture, Forest Service.

*Raley, C.M. 1986. Availability and use of invertebrate food resources by high elevation riparian birds in Southeastern Wyoming. Graduate Thesis, University of Wyoming, Laramie, Wyoming.

Robertson, D. 1991. Conservation of Neotropical Birds. U.S. Department of Agriculture, Forest Service. The Friday Newsletter. **20**: 1-2.

Romme, W. H.; Jamieson, D.W.; Redders, J.S.; Bigsby, G.; Lindsey, J.P.; Kendall, D.; Cowen, R.; Kreykes, T.; Spencer, A.W.; Ortega, J. C. 1992. Old-Growth forests of the San Juan National Forest in Southwestern Colorado. In: Old-Growth Forests in the Southwest and Rocky Mountain Regions - Proceedings of a Workshop. March 9-13, Portal, Arizona. U.S. Department of Agriculture, Forest Service, Gen Tech Rep RM-213, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colo. pages 154-165.

Ryder, R. 1978. Occurrence and habitat requirements of avian species found in the Rocky Mountain Region. U.S. Department of Agriculture, Forest Service, Region 2.

Salt, G.W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole. Condor 59: 373-393.

Schulz, T.T.; Leininger, W.C. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. Great Basin Naturalist. 51: 286-292.

Scott, V.E.; Crouch, G.L. 1988a. Summer birds and mammals of aspen-conifer forests in West-Central Colorado. U.S. Department of Agriculture, Forest Service, Research Note RM-280, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colorado.

Scott, V.E.;, Crouch, G.L. 1988b. Breeding birds and small mammals in pole-sized lodgepole pine and small inclusions of aspen in Central Colorado. U.S. Department of Agriculture, Forest Service, Research Note RM-482, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colorado.

Scott, V.E.; Svoboda, P.L. 1980. Cavity-nesting birds and forest management. IN: Workshop for Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Feb. 11-14, 1980. U.S. Department of Agriculture, Forest Service, Gen Tech Rep INT-86, Rocky Mountain Forest and Range Experimental Station, Ogden, UT.

Smith, K.G. 1980. Nongame Birds of the Rocky Mountain Spruce-Fir Forests and Their Management. IN: Workshop for Management of Western Forests and Grasslands for Nongame Birds, Salt Lake City, Feb. 11-14, 1980. U.S. Department of Agriculture, Forest Service, Gen Tech Rep INT-86, Rocky Mountain Forest and Range Experimental Station, Ogden, UT.

ADDITIONAL REFERENCES NOT CITED

Austin, D.D., Perry, M.L. 1979. Birds in six communities within a lodgepole pine forest. Journal of Forestry, Sept. 1989: 584-586.

Geils, B.W., Martin, S.K., Barrett, R. H. 1993. Evaluation of the impacts of forest health on wildlife habitat in mixed conifer forests of Northeastern Sierra Nevada. Coop. Agree. 28-C2-663 UCB-RMS. U.S. Department of Agriculture, Forest Service.

*Hegel, D.A., Anderson, S.H. 1990. Habitat use, diet and reproduction of Merriam's Turkeys near Laramie Peak, Wyoming. Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, Wyoming.

Jones, B.W. 1993. The Influence of grove size on bird species richness in Aspen Parklands. Wilson Bulletin **105**: 256-264.

Knopf, F.L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. Paper presented at symposium on riparian ecosystems and their management: Reconciling conflicting uses, Tucson, AR, Apr. 16-18, 1985.

Koford, R.R, Dunning, J.B, Ribic, C.A, Finch, D.M. 1994. A glossary for Avian Conservation Biology. Wilson Bulletin: 121-137.

Lennartz, M.R.; Bjugstad, A.J. 1975. Information needs to manage forest and range habitats for nongame birds. Gen Tech Rep WO-1, U.S. Department of Agriculture, Forest Service, Washington, D.C.

McClanahan, T.R.; Wolfe, R.W. 1993. Accelerating forest succession in a fragmented landscape: The role of birds and perches. Conservation Biology 7: 279-288.

Saav, V. 1994. Bird responses to stand-replacement fire in Ponderosa/Douglas Fir Forests. U.S. Department of Agriculture, Forest Service. Boise FSL.

Sieg, C.H. 1991. Rocky Mountain Juniper Woodlands: Year-Round Avian Habitat. Research Paper RM-296. U. S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station.

Webb, B. 1983. Distribution and nesting requirements of montane forest owls in Colorado. C.F.O. Journal. Vol 17, No. 1: 2-8.

Yahner, R.H. 1993. Effects of long-term forest clear-cutting on wintering and breeding birds. The Wisconsin Bulletin **105**: 239-255.

APPENDIX 11

ACREAGE MEASUREMENTS OF COVER TYPE

The tables in this appendix are from Baker (1994) Table A-22. Acreages were calculated by GIS from information in the RIS database of the Medicine Bow National Forest as of Fall, 1994.

Major upland cover types of Biological Diversity Analysis Areas (BDAs) and Biological Diversity Analysis Untis (BDUs) are presented in Table AP11.1. Acres of riparian cover types are in Table 7.9 of Chapter 7. RIS categories were grouped into the following categories:

CONIF - acres of upland coniferous forest
DECID - acres of upland deciduous forest (aspen)
SHRUB - acres of upland shrubland including sagebrush, antelope bitterbrush and others.
FORB - acres of upland forblands
GRASS - acres of upland grassland
NonVeg - upland acres with no vegetation
UPSUM - sum of upland acres for the cover types listed above
RIPAR - sum of riparian acres from Table 7.9
GSUM - grand sum of all acres in the BDU

The bottom line in each BDA category gives the sum of acres for each cover type within the BDA. Sums are also given for Snowy Range North and South, Laramie Mountains North and South. Sums for each mountain range and a Medicine Bow National Forest sum are also provided. This permits examination of cover type acreages at several scales.

Acres within BDUs, summed for BDAs, for each major tree species are presented in Table AP11.2. Sum of acres for each BDU for CONIF and TAA (Aspen) were used for the CONIF and DECID categories in Table AP11.1. The cover type codes are:

TSF - tree, spruce-fir
TLP - tree, lodgepole pine
LPSF - lodgepole pine and spruce-fir (sum of TSF and TLP)
TLI - limber pine
TPP - ponderosa pine
TDF - Douglas fir
TPJ - Rocky Mountain juniper
CONIF - sum of columns 1-5,7
TAA - aspen
Totals - sum of all tree categories (1-7)

Acres for each tree species are also summed by areas within mountain ranges, for each mountian range and for the entire Forest.

The acreages presented in these two tables correspond with the maps for cover type in Figure 6.2. These acreages, stratified by stand age where available, are the basis for acreages elsewhere in the report describing cover-type age composition of watersheds. They are also the basis for the landscape measurements by Baker (1994) discussed in Chapter 6.

Figures AP11.1 and AP11.2 are based in Tables AP 11.1 and AP11.2. They describe the diversity of cover types and tree species at the scale of the BDA. They are BDA scale graphs of Figures 6.3 and 6.7 which present the same data summarized by mountain range. Similar graphs could be prepared for each BDU (96 total).

TABLE AP11.1 Acres of upland cover types, riparian cover type sum and total acres within each BDU and BDA. From Baker (1994) Table A-2. Cover types include all seral stages.

Upland Cover Types

				8	9	10	11			
SM-NW	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	UPSUM	RIPAR	GSUM
Savery Creek	1	9497	798	3671	0	49	16	14031	682	14713
Dirtyman Creek	2	4823	1701	868	0	0	40	7432	255	7687
Big Sandstone Creek	3	14964	6989	3921	0	395	204	26473	1126	27599
Jack Creek	13	10647	618	2369	0	26	7	13667	802	14469
North Spring Creek	14	12293	380	2627	0	47	0	15347	768	16115
South Spring Creek	15	8445	275	1431	0	194	0	10345	240	10585
Cow Creek	16	8750	579	1363	0	420	73	11185	372	11557
	Sum	69419	11340	16250	0	1131	340	98480	4245	102725

SM-SW	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Little Sandstone Creek	4	2939	7663	3819	0	182	73	14676	785	15461
Big Gulch	5	116	2404	2552	0	329	3	5404	186	5590
E. Sweetwater Gulch	6	127	154	1816	0	18	24	2139	52	2191
Lower Battle Creek	7	169	5412	6967	0	138	233	12919	611	13530
Cottonwood Creek	8	188	2464	5168	0	71	0	7891	429	8320
Roaring Fk LSR	9	10098	0	699	219	425	33	11474	552	12026
N. Fk LSR	10	17739	7381	578	0	618	171	26487	1978	28465
Upper Battle Creek	11	10957	4537	958	9	1030	153	17644	786	18430
W. Fk. Battle Creek	12	5360	4247	878	0	1350	231	12066	377	12443
	Sum	47693	34262	23435	228	4161	921	110700	5756	116456

SM-Enc. River	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
N. Fk Encampment River	17	10489	838	1112	0	293	232	12964	1071	14035
S. Fk. Miner Creek	18	10820	906	1120	0	277	15	13138	781	13919
Hog Park Creek	19	8808	174	224	0	949	39	10194	1594	11788
Encampment River Canyon	20	10696	321	671	0	77	5	11770	917	12687
Billie Creek	21	4677	437	1989	0	0	1	7104	555	7659
E. Fk Encampment River	22	10451	0	76	0	69	26	10622	1398	12020
	Sum	55941	2676	5192	0	1665	318	65792	6316	72108

TABLE AP11.1 Acres of upland cover types, riparian cover type sum and total acres within each BDU and BDA. From Baker (1994) Table A-2. Cover types include all seral stages.

SM-SE	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Beaver Creek	23	8829	473	2260	0	10	1	11573	817	12390
Middle Fk Big Creek	24	14201	768	2729	0	122	27	17847	1209	19056
Bear Creek	25	3483	1093	685	0	0	213	5474	218	5692
S. Fk Big Creek	26	4365	0	3438	0	18	0	7821	421	8242
	Sum	30878	2334	9112	0	150	241	42715	2665	45380
SIERRA MADRE TOTALS	Sum	203931	50612	53989	228	7107	1820	317687	18982	336669
SNOWY RANGE										
				8	9	10	11			
SRN-West	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
S. Fk. Lake Creek	27	3337	593	1608	0	17	0	5555	222	5777
N. Cedar Creek	28	3229	1151	984	0	0	1	5365	249	5614
Rankin Creek	29	4735	1384	1000	0	26	0	7145	274	7419
Pass Creek	30	12320	379	303	0	98	29	13129	1219	14348
S. Cedar Creek	31	4540	1093	804	0	63	278	6778	294	7072
Lower N. Brush Creek	32	9308	393	334	0	164	0	10199	660	10859
Upper N. Brush Creek	33	10412	0	346	0	844	408	12010	1761	13771
S. Brush Creek	34	11143	31	435	0	1259	759	13627	1170	14797
Lower Brush Creek	35	7501	639	484	0	49	0	8673	526	9199
N. Cottonwood Creek	36	4776	521	1230	0	237	0	6764	282	7046
Middle French Creek	37	11957	165	259	0	770	323	13474	831	14305
Upper S. French Creek	38	10853	121	120	67	1889	1173	14223	756	14979
Lower S. French Creek	39	5450	814	1186	0	171	4	7625	535	8160
	Sum	99561	7284	9093	67	5587	2975	124567	8779	133346

TABLE AP11.1 Acres of upland cover types, riparian cover type sum and total acres within each BDU and BDA. From Baker (1994) Table A-2. Cover types include all seral stages.

SRN-Northeast	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Fourmile Creek	60	9827	266	74	0	183	0	10350	304	10654
North Rock Creek	61	19989	211	1681	0	1018	53	22952	993	23945
South Rock Creek	62	15473	0	227	0	2214	55	17969	1573	19542
W. Medicine Bow R	63	7052	45	49	0	170	21	7337	1033	8370
Upper Medicine Bow River	64	2886	0	1289	34	3444	231	7884	884	8768
Lower Medicine Bow River	65	7138	85	964	0	405	34	8626	1811	10437
East Medicine Bow River	66	8216	81	53	0	122	86	8558	541	9099
Wagonhound Creek	67	6179	23	440	0	116	0	6758	377	7135
	Sum	76760	711	4777	34	7672	480	90434	7516	97950

SRN- East Central	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
South Fork	56	7467	534	711	0	116	5	8833	828	9661
Middle Fork	57	16400	69	856	0	746	8	18079	1502	19581
North Fork	58	21365	912	1614	1348	3123	359	28721	2200	30921
Mill Creek	59	5896	760	64	0	761	0	7481	216	7697
	Sum	51128	2275	3245	1348	4746	372	63114	4746	67860
SNOWY RANGE NORTH TOTALS		227449	10270	17115	1449	18005	3827	278115	21041	299156

SNOWY RANGE SRS-Wilderness	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Mullen Creek	40	16817	923	1981	0	1684	14	21419	1096	22515
Cottonwood Creek	41	6842	233	1274	0	956	0	9305	573	9878
Platte River	42	15007	1015	7461	0	103	121	23707	1473	25180
	Sum	38666	2171	10716	0	2743	135	54431	3142	57573

TABLE AP11.1 Acres of upland cover types, riparian cover type sum and total acres within each BDU and BDA. From Baker (1994) Table A-2. Cover types include all seral stages.

SRS-Central	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Pelton Creek	43	18225	406	1571	0	90	0	20292	2277	22569
Lower Douglas Creek	44	10517	496	780	0	1052	0	12845	1288	14133
Mowberg Creek	45	5430	4	242	0	77	0	5753	980	6733
Lake Creek	46	9277	0	861	0	191	0	10329	1115	11444
Muddy Creek	47	6038	0	145	0	149	0	6332	742	7074
Middle Douglas Creek	48	9948	0	244	0	86	0	10278	864	11142
Devils Gate Creek	49	6262	39	207	0	129	0	6637	555	7192
Upper Douglas Creek	50	9884	0	470	0	336	10	10700	1513	12213
	Sum	75581	945	4520	0	2110	10	83166	9344	92510

SRS-Southeast	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Boswell Creek	51	7177	329	2505	0	63	7	10081	849	10930
Bear Creek	52	9020	1300	3924	0	83	45	14372	982	15354
Lake Owen Creek	53	14028	1047	3897	0	868	2	19842	1918	21760
Johns Creek	54	3686	140	2131	0	1835	100	7892	404	8296
Buckeye Creek	55	4622	209	725	0	423	3	5982	442	6424
	Sum	38533	3025	13182	0	3272	157	58169	4409	62578
SNOWY RANGE SOUTH TOT		152780	6141	28418	0	8125	302	195766	16895	212661
SNOWY RANGE TOTAL		380229	16411	45533	1449	26130	4129	473881	37936	511817
LOWER BOW TOTAL		584160	67023	99522	1677	33237	5949	791568	56918	848486

TABLE AP11.1 Acres of upland cover types, riparian cover type sum and total acres within each BDU and BDA. From Baker (1994) Table A-2. Cover types include all seral stages.

LARAMIE MTS- N										
LRMN-Northwest	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
W. Fk. Deer Creek	71	1136	3	0	0	5	0	1144	87	1231
Bates Creek	72	2220	1	158	0	21	0	2400	122	2522
Upper Deer Creek	73	12366	709	2516	0	105	98	15794	552	16346
Virden Creek	74	995	37	16	0	0	4	1052	17	1069
Box Elder Creek	75	8351	106	113	0	34	92	8696	233	8929
E. Box Elder Creek	76	4246	10	136	0	121	34	4547	112	4659
Standing Rock Creek	77	228	9	97	0	128	0	462	5	467
Meadow Creek	78	5270	70	607	0	814	295	7056	333	7389
Little Med. Bow River	79	4523	6	14	0	19	34	4596	228	4824
Sheep Creek	80	4562	2	169	0	302	6	5041	390	5431
	Sum	43897	953	3826	0	1549	563	50788	2079	52867
LRMN-N. Central	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Rocky Ford Cr.	81	613	0	21	0	3	11	648	38	686
Latham Creek	82	1165	0	0	0	1	5	1171	22	1193
W. Fk. LaBonte Canyon	83	1914	33	0	0	0	0	1947	38	1985
La Bonte Creek	84	21696	562	667	0	72	74	23071	931	24002
	Sum	25388	595	688	0	76	90	26837	1029	27866
Lar Mts North	Sum	69285	1548	4514	0	1625	653	77625	3108	80733

TABLE AP11.1 Acres of upland cover types, riparian cover type sum and total acres within each BDU and BDA. From Baker (1994) Table A-2. Cover types include all seral stages.

LRMS- S.Central	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Mill Creek	85	13	0	0	0	3	0	16	0	16
Lower Horseshoe Creek	86	6923	57	563	0	192	1	7736	66	7802
Upper Horseshoe Creek	87	10802	171	995	0	361	135	12464	807	13271
Roaring Fork	88	13207	8	60	0	438	0	13713	264	13977
Cottonwood Creek	89	13228	52	57	0	50	64	13451	140	13591
	Sum	44173	288	1675	0	1044	200	47380	1277	48657

LRMS- Southwest	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Eggleston Creek	90	9232	399	1413	0	297	90	11431	1118	12549
Bear Creek	91	17450	61	464	0	161	37	18173	1404	19577
N. Laramie River	92	3678	0	30	0	0	10	3718	128	3846
	Sum	30360	460	1907	0	458	137	33322	2650	35972

LRMS- Southern	BDU	CONIF	DECID	SHRUB	FORB	GRASS	NonVeg	SUM	RIPAR	GSUM
Claude Irvine Creek	93	5315	28	542	0	7	12	5904	219	6123
Owen Creek	94	1217	0	1	0	6	13	1237	61	1298
Dry Laramie River	95	1769	0	0	0	5	6	1780	60	1840
Luman Creek	96	3206	0	221	0	22	27	3476	74	3550
	Sum	11507	28	764	0	40	58	12397	414	12811
Lar Mts. South Total	Sum	86040	776	4346	0	1542	395	93099	4341	97440
Lar Mts Total	Sum	155325	2324	8860	0	3167	1048	170724	7449	178173
East Side Total	Sum	164342	4066	13830	1585	13120	1744	198687	10265	208952
MBNF TOTAL	Sum	739485	69347	108382	1677	36404	6997	962292	64367	1026659

TABLE AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

SIERRA MADRE	A-2	1	2		3	4	5	7		6	
SM-NW	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Savery Creek	1	1501	7996	9497	0	0	0	0	9497	798	10295
Dirtyman Creek	2	140	4683	4823	0	0	0	0	4823	1701	6524
Big Sandstone Creek	3	2881	11945	14826	0	0	138	0	14964	6989	21953
Jack Creek	13	2639	8008	10647	0	0	0	0	10647	618	11265
North Spring Creek	14	3025	9265	12290	3	0	0	0	12293	380	12673
South Spring Creek	15	4918	3512	8430	15	0	0	0	8445	275	8720
Cow Creek	16	4289	4434	8723	0	0	0	27	8750	579	9329
	Sum	19393	49843	69236	18	0	138	27	69419	11340	80759

SM-SW	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Little Sandstone Creek	4	68	2828	2896	0	0	43	0	2939	7663	10602
Big Gulch	5	116	0	116	0	0	0	0	116	2404	2520
E. Sweetwater Gulch	6	30	97	127	0	0	0	0	127	154	281
Lower Battle Creek	7	3	166	169	0	0	0	0	169	5412	5581
Cottonwood Creek	8	14	174	188	0	0	0	0	188	2464	2652
Roaring Fk LSR	9	2714	1844	4558	0	0	4841	699	10098	0	10098
N. Fk LSR	10	13048	4677	17725	0	0	14	0	17739	7381	25120
Upper Battle Creek	11	7572	3385	10957	0	0	0	0	10957	4537	15494
W. Fk. Battle Cr	12	2487	2873	5360	0	0	0	0	5360	4247	9607
	Sum	26052	16044	42096	0	0	4898	699	47693	34262	81955

SM-Enc. River	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
N. Fk Encampment River	17	7986	2503	10489	0	0	0	0	10489	838	11327
S. Fk. Miner Creek	18	5174	5646	10820	0	0	0	0	10820	906	11726
Hog Park Creek	19	2942	5866	8808	0	0	0	0	8808	174	8982
Encampment River Canyo	20	1800	8896	10696	0	0	0	0	10696	321	11017
Billie Creek	21	860	3817	4677	0	0	0	0	4677	437	5114
E. Fk Encampment River	22	2813	7638	10451	0	0	0	0	10451	0	10451
	Sum	21575	34366	55941	0	0	0	0	55941	2676	58617

TABLE AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

SM-SE	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Beaver Creek	23	703	8126	8829	0	0	0	0	8829	473	9302
Middle Fk Big Creek	24	1412	12764	14176	0	0	25	0	14201	768	14969
Bear Creek	25	0	3378	3378	0	0	105	0	3483	1093	4576
S. Fk Big Creek	26	0	3169	3169	16	217	963	0	4365	0	4365
	Sum	2115	27437	29552	16	217	1093	0	30878	2334	33212
SIERRA MADRE TOTALS		69135	127690	196825	34	217	6129	726	203931	50612	254543

SNOWY RANGE

SRN-West	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
S. Fk. Lake Creek	27	823	2514	3337	0	0	0	0	3337	593	3930
N. Cedar Creek	28	1161	2068	3229	0	0	0	0	3229	1151	4380
Rankin Creek	29	1709	3126	4835	0	0	0	0	4835	1384	6219
Pass Creek	30	5700	6620	12320	0	0	0	0	12320	379	12699
S. Cedar Creek	31	2317	2223	4540	0	0	0	0	4540	1093	5633
Lower N. Brush Creek	32	3652	5656	9308	0	0	0	0	9308	393	9701
Upper N. Brush Creek	33	8054	2358	10412	0	0	0	0	10412	0	10412
S. Brush Creek	34	7176	3967	11143	0	0	0	0	11143	31	11174
Lower Brush Creek	35	1508	5973	7481	0	20	0	0	7501	639	8140
N. Cottonwood Creek	36	96	4546	4642	0	23	111	0	4776	521	5297
Middle French Creek	37	6256	5691	11947	0	0	10	0	11957	165	12122
Upper S. French Creek	38	6693	4160	10853	0	0	0	0	10853	121	10974
Lower S. French Creek	39	746	4520	5266	0	0	184	0	5450	814	6264
	Sum	45891	53422	99313	0	43	305	0	99661	7284	106945

TABLE AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

SRN-Northeast	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Fourmile Creek	60	1485	8116	9601	226	0	0	0	9827	266	10093
North Rock Creek	61	8125	11404	19529	177	0	283	0	19989	211	20200
South Rock Creek	62	7453	7709	15162	311	0	0	0	15473	0	15473
W. Medicine Bow R	63	3142	3910	7052	0	0	0	0	7052	45	7097
Upper Medicine Bow River	64	2824	62	2886	0	0	0	0	2886	0	2886
Lower Medicine Bow River	65	3333	3805	7138	0	0	0	0	7138	85	7223
East Medicine Bow River	66	4174	4042	8216	0	0	0	0	8216	81	8297
Wagonhound Creek	67	1017	5162	6179	0	0	0	0	6179	23	6202
	Sum	31553	44210	75763	714	0	283	0	76760	711	77471

SRN- East Central	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
South Fork	56	579	6273	6852	46	0	569	0	7467	534	8001
Middle Fork	57	4308	11677	15985	213	0	202	0	16400	69	16469
North Fork	58	10013	11104	21117	223	0	25	0	21365	912	22277
Mill Creek	59	1222	4630	5852	44	0	0	0	5896	760	6656
	Sum	16122	33684	49806	526	0	796	0	51128	2275	53403

SNOWY RANGE NORTH TOTAL											
		93566	131316	224882	1240	43	1384	0	227549	10270	237819

SNOWY RANGE SOUTH

SRS-Wilderness	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Mullen Creek	40	4956	11336	16292	0	0	525	0	16817	923	17740
Cottonwood Creek	41	685	5467	6152	0	0	690	0	6842	233	7075
Platte River	42	106	11209	11315	169	86	3276	161	15007	1015	16022
	Sum	5747	28012	33759	169	86	4491	161	38666	2171	40837

TABLE AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

SRS-Central	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Pelton Creek	43	883	17342	18225	0	0	0	0	18225	406	18631
Lower Douglas Creek	44	131	10236	10367	0	45	105	0	10517	496	11013
Mowberg Creek	45	146	5284	5430	0	0	0	0	5430	4	5434
Lake Creek	46	406	8871	9277	0	0	0	0	9277	0	9277
Muddly Creek	47	438	5600	6038	0	0	0	0	6038	0	6038
Middle Douglas Creek	48	2170	7778	9948	0	0	0	0	9948	0	9948
Devils Gate Creek	49	275	5987	6262	0	0	0	0	6262	39	6301
Upper Douglas Creek	50	2842	7042	9884	0	0	0	0	9884	0	9884
	Sum	7291	68140	75431	0	45	105	0	75581	945	76526

SRS-Southeast	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Boswell Creek	51	287	6771	7058	15	0	104	0	7177	329	7506
Bear Creek	52	111	8574	8685	0	0	335	0	9020	1300	10320
Lake Owen Creek	53	638	12837	13475	22	261	270	0	14028	1047	15075
Johns Creek	54	0	3580	3580	0	106	0	0	3686	140	3826
Buckeye Creek	55	109	3613	3722	0	721	179	0	4622	209	4831
	Sum	1145	35375	36520	37	1088	888	0	38533	3025	41558

SNOWY RANGE SOUTH T	Sum	14183	131527	145710	206	1219	5484	161	152780	6141	158921
SNOWY RANGE TOTAL	Sum	107749	262843	370592	1446	1262	6868	161	380329	16411	396740
LOWER BOW TOTAL	Sum	176884	390533	567417	1480	1479	12997	887	584260	67023	651283

E AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

SHERMAN MTS.	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	
Telephone Creek	68	0	269	269	159	728	151	0	1307	261	1568
Lodgepole Creek	69	20	3074	3094	125	1835	6	0	5060	925	5985
Crow Creek	70	0	2339	2339	114	6035	529	0	9017	1742	10759
	Sum	20	5682	5702	398	8598	686	0	15384	2928	18312

LARAMIE MTS North											Totals
LRMN-Northwest	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	
W. Fk. Deer Creek	71	30	800	830	282	24	0	0	1136	3	1139
Bates Creek	72	0	728	728	1492	0	0	0	2220	1	2221
Upper Deer Creek	73	0	9074	9074	2751	541	0	0	12366	709	13075
Virden Creek	74	0	513	513	30	452	0	0	995	37	1032
Box Elder Creek	75	0	6439	6439	853	1059	0	0	8351	106	8457
E. Box Elder Creek	76	35	3898	3933	0	272	41	0	4246	10	4256
Standing Rock Creek	77	163	48	211	2	6	9	0	228	9	237
Meadow Creek	78	253	4461	4714	31	480	45	0	5270	70	5340
Little Med. Bow River	79	145	2421	2566	1458	499	0	0	4523	6	4529
Sheep Creek	80	2	3433	3435	341	786	0	0	4562	2	4564
	Sum	628	31815	32443	7240	4119	95	0	43897	953	44850

LRMN- N. Central	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Rocky Ford Creek	81	0	555	555	10	48	0	0	613	0	613
Latham Creek	82	0	1047	1047	0	118	0	0	1165	0	1165
W. Fk. La Bonte Canyon	83	26	891	917	47	927	23	0	1914	33	1947
La Bonte Creek	84	118	8070	8188	871	11590	977	70	21696	562	22258
	Sum	144	10563	10707	928	12683	1000	70	25388	595	25983
Lar. Mts. North	Sum	772	42378	43150	8168	16802	1095	70	69285	1548	70833

TABLE AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

Laramie Mts. South

LRMS-S. Central	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Mill Creek	85	0	0	0	0	13	0	0	13	0	13
Lower Horseshoe Creek	86	0	0	0	0	6923	0	0	6923	57	6980
Upper Horseshoe Creek	87	0	5619	5619	628	4555	0	0	10802	171	10973
Roaring Fork	88	501	1460	1961	0	11246	0	0	13207	8	13215
Cottonwood Creek	89	103	1083	1186	43	11999	0	0	13228	52	13280
	Sum	604	8162	8766	671	34736	0	0	44173	288	44461

LRMS- Southwest	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Eggleston Creek	90	0	767	767	2042	6422	1	0	9232	399	9631
Bear Creek	91	45	6183	6228	27	11027	168	0	17450	61	17511
N. Laramie River	92	0	0	0	3678	0	0	0	3678	0	3678
	Sum	45	6950	6995	5747	17449	169	0	30360	460	30820

LRMS- Southern	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Claude Irvine Creek	93	0	0	0	0	5315	0	0	5315	28	5343
Owen Creek	94	0	0	0	0	1217	0	0	1217	0	1217
Dry Laramie River	95	0	0	0	0	1769	0	0	1769	0	1769
Luman Creek	96	0	0	0	139	3067	0	0	3206	0	3206
	Sum	0	0	0	139	11368	0	0	11507	28	11535
Lar. Mts. S. Total	Sum	649	15112	15761	6557	63553	169	0	86040	0	86040
Lar. Mts. Total	Sum	1421	57490	58911	14725	80355	1264	70	155325	1548	156873
East Side Total	Sum	1441	63172	64613	15123	88953	1950	70	170709	4476	175185
MBNF Total	Sum	178325	453705	632030	16603	90432	14947	957	754969	71499	826468

TABLE AP11.2 Acres of each major tree species within each BDU and BDA. From Baker (1994) Table A-2. Cover types for trees include all seral stages from grass-forb of clearcuts to old growth.

Laramie Mts. South

LRMS-S. Central	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Mill Creek	85	0	0	0	0	13	0	0	13	0	13
Lower Horseshoe Creek	86	0	0	0	0	6923	0	0	6923	57	6980
Upper Horseshoe Creek	87	0	5619	5619	628	4555	0	0	10802	171	10973
Roaring Fork	88	501	1460	1961	0	11246	0	0	13207	8	13215
Cottonwood Creek	89	103	1083	1186	43	11999	0	0	13228	52	13280
	Sum	604	8162	8766	671	34736	0	0	44173	288	44461

LRMS- Southwest	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Eggleston Creek	90	0	767	767	2042	6422	1	0	9232	399	9631
Bear Creek	91	45	6183	6228	27	11027	168	0	17450	61	17511
N. Laramie River	92	0	0	0	3678	0	0	0	3678	0	3678
	Sum	45	6950	6995	5747	17449	169	0	30360	460	30820

LRMS- Southern	BDU	TSF	TLP	LPSF	TLI	TPP	TDF	TPJ	CONIF	TAA	Totals
Claude Irvine Creek	93	0	0	0	0	5315	0	0	5315	28	5343
Owen Creek	94	0	0	0	0	1217	0	0	1217	0	1217
Dry Laramie River	95	0	0	0	0	1769	0	0	1769	0	1769
Luman Creek	96	0	0	0	139	3067	0	0	3206	0	3206
	Sum	0	0	0	139	11368	0	0	11507	28	11535
Lar. Mts. S. Total	Sum	649	15112	15761	6557	63553	169	0	86040	0	86040
Lar. Mts. Total	Sum	1421	57490	58911	14725	80355	1264	70	155325	1548	156873
East Side Total	Sum	1441	63172	64613	15123	88953	1950	70	170709	4476	175185
MBNF Total	Sum	178325	453705	632030	16603	90432	14947	796	754808	71499	826307

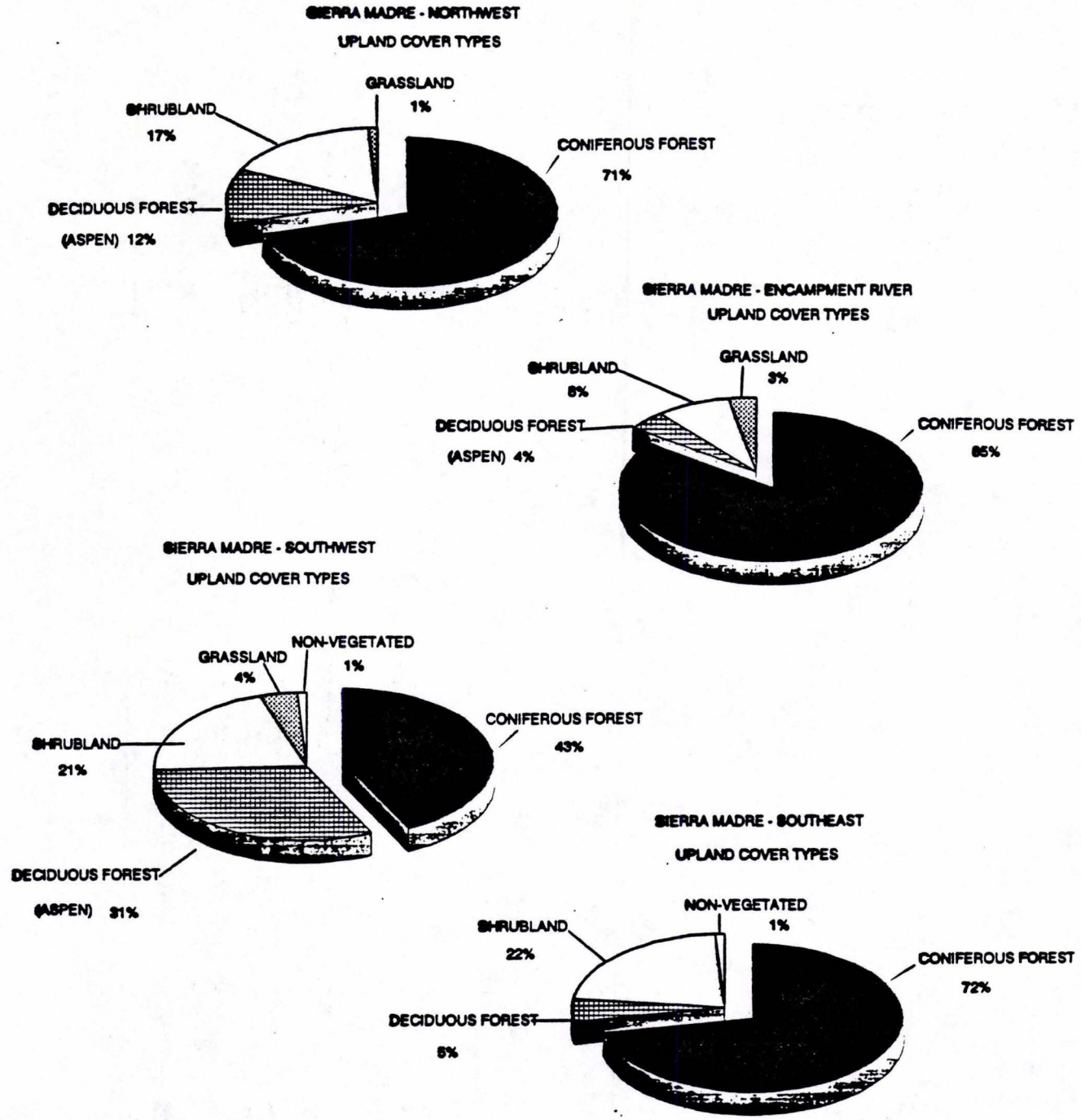


FIGURE AP11.1 Percent cover of major upland cover types within each BDA. See Figure 6.3 for percentages within mountain ranges. Cover types include all seral stages.

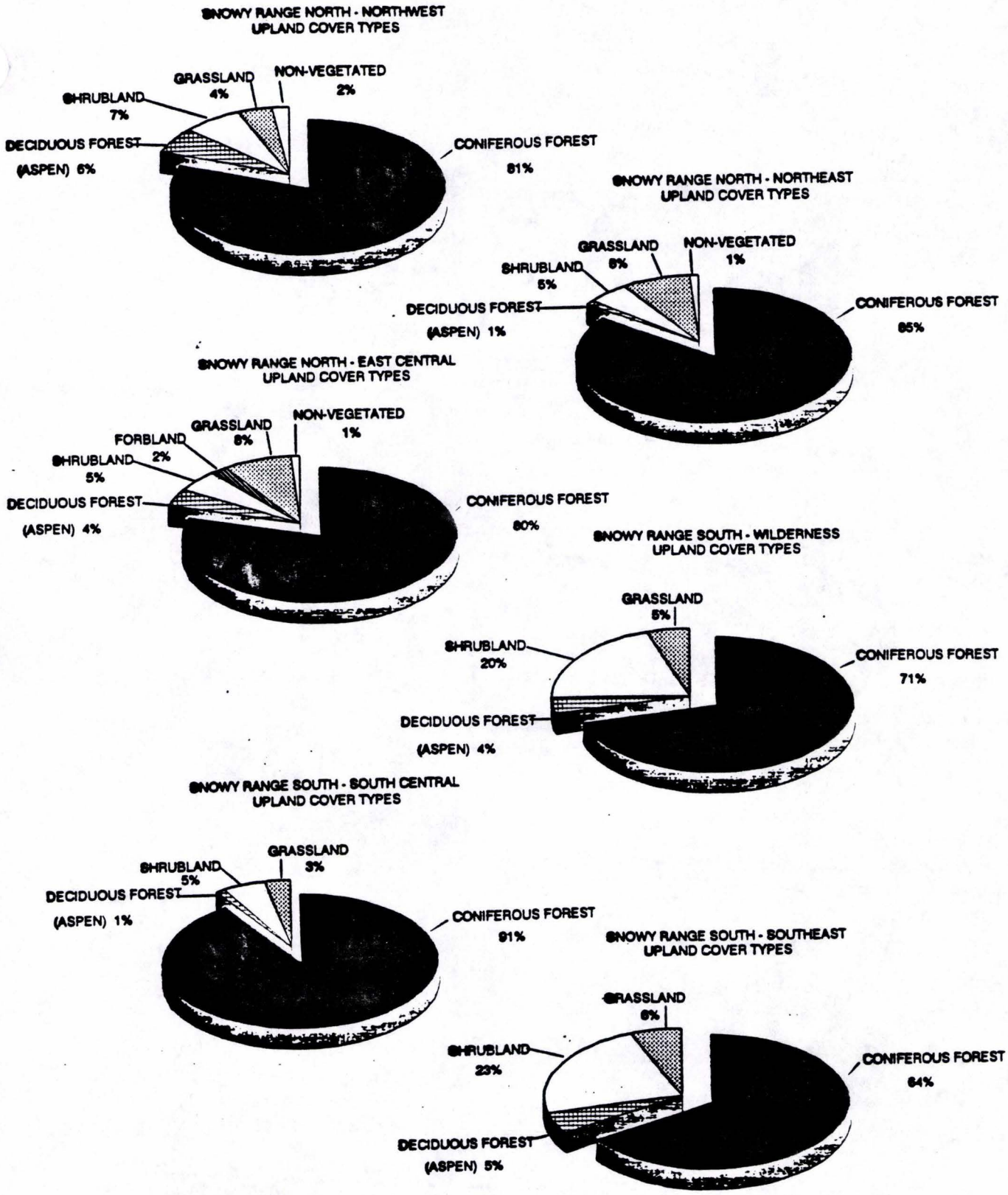


FIGURE AP11.1 Percent cover of major upland cover types within each BDA. See Figure 6.3 for percentages within mountain ranges. Cover types include all seral stages.

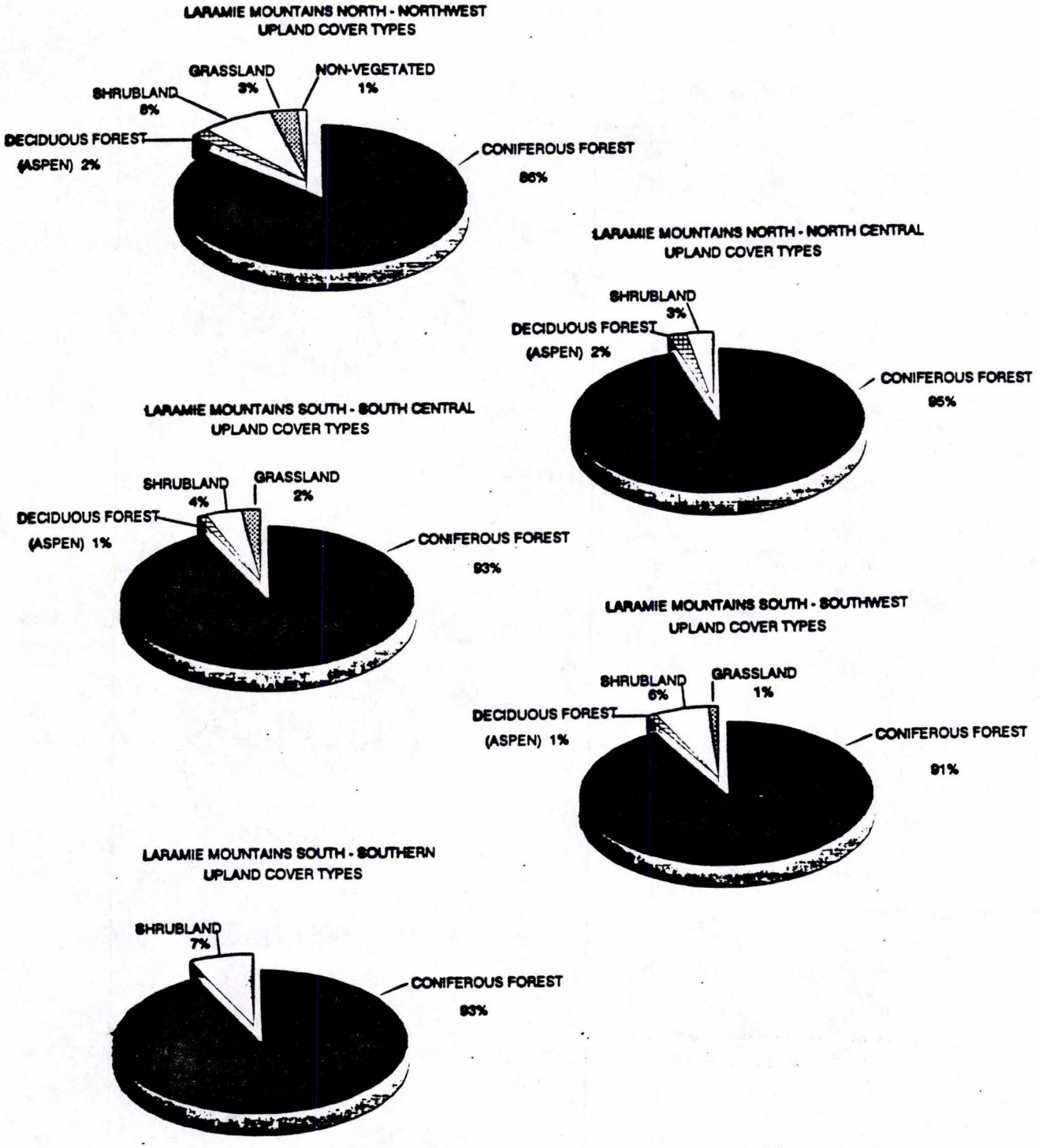


FIGURE AP11.1 Percent cover of major upland cover types within each BDA. See Figure 6.3 for percentages within mountain ranges. Cover types include all seral stages.

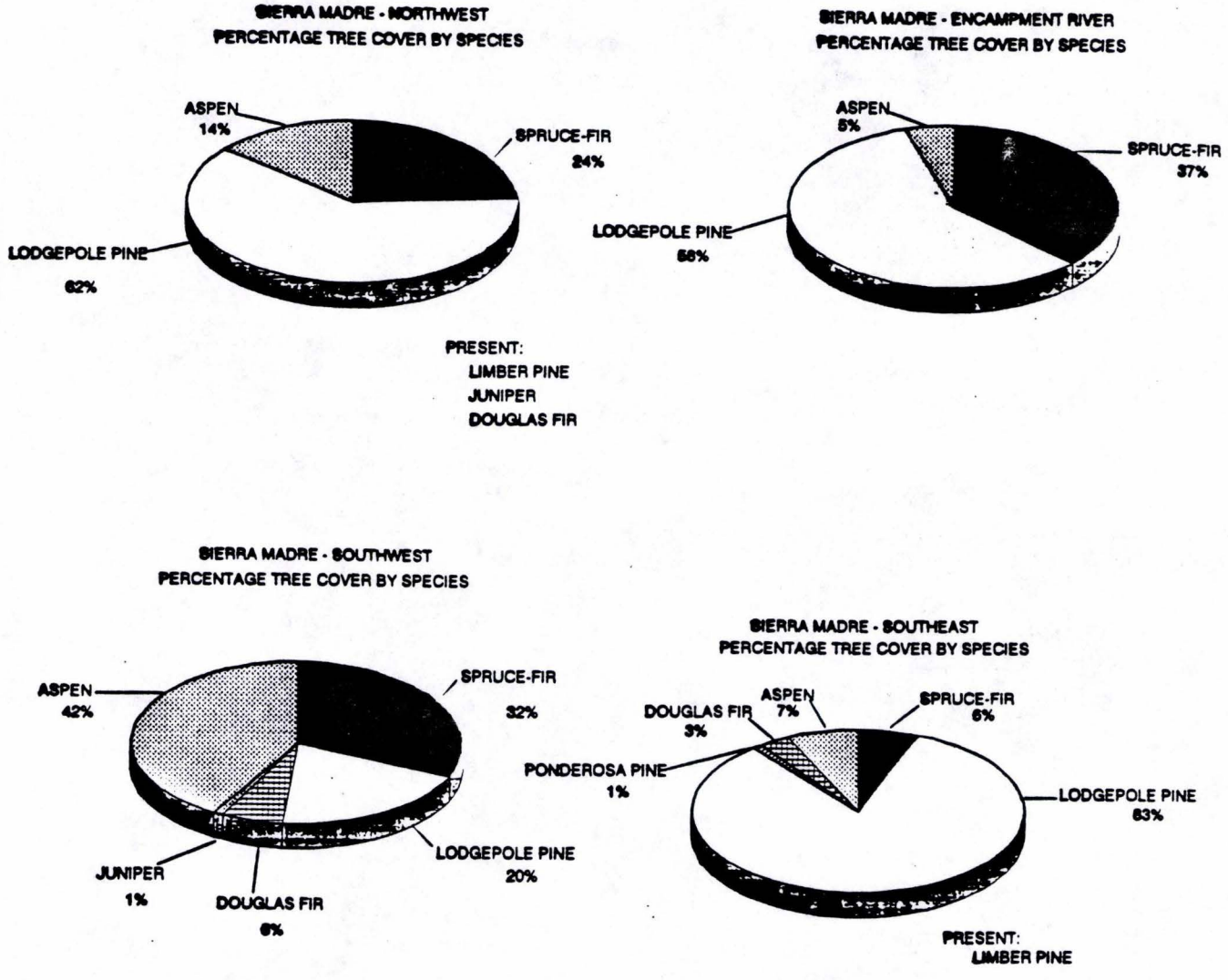
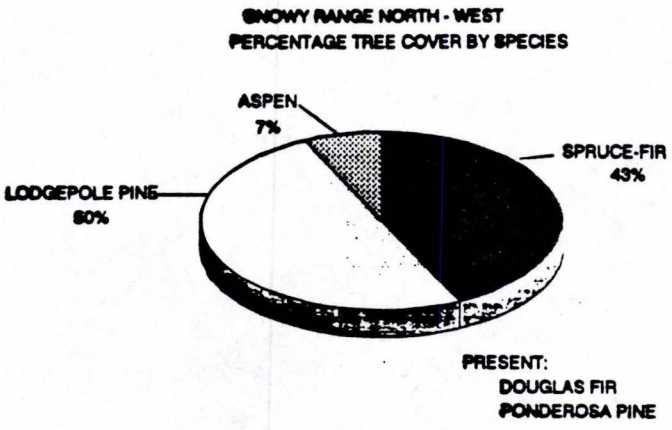
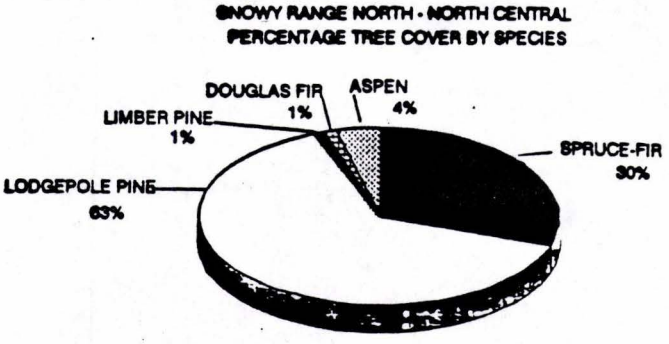
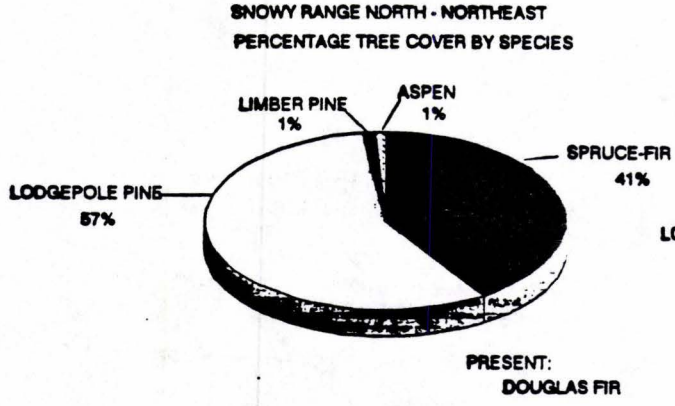
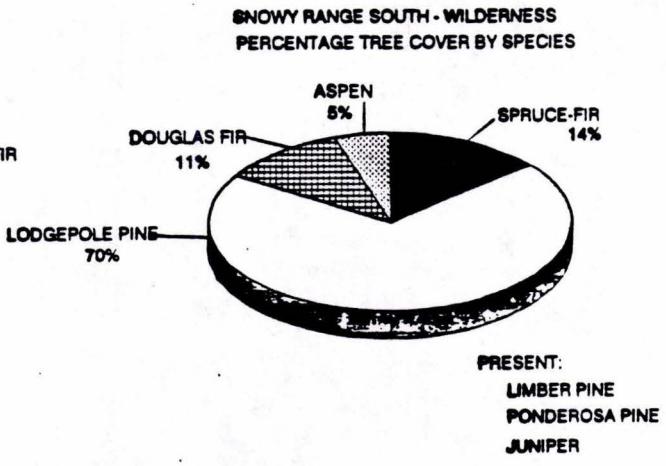


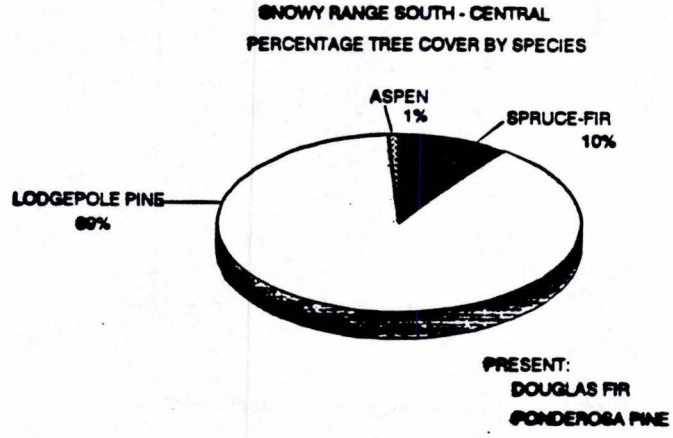
FIGURE AP11.2 Percent cover of tree species for each BDA. See Figure 6.7 for percent cover within mountain ranges. Percent cover includes all seral stages.











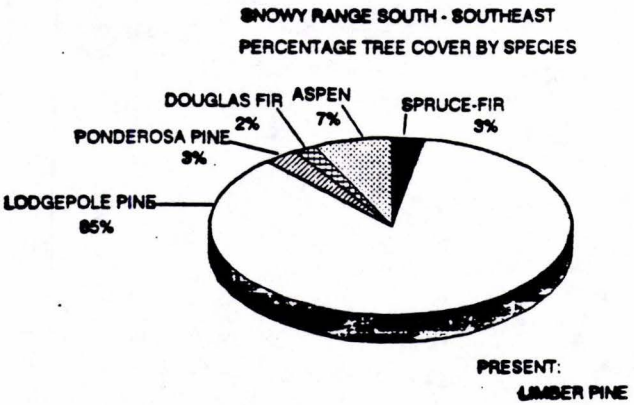


FIGURE AP11.2 Percent cover of tree species for each BDA. See Figure 6.7 for percent cover within mountain ranges. Percent cover includes all seral stages.

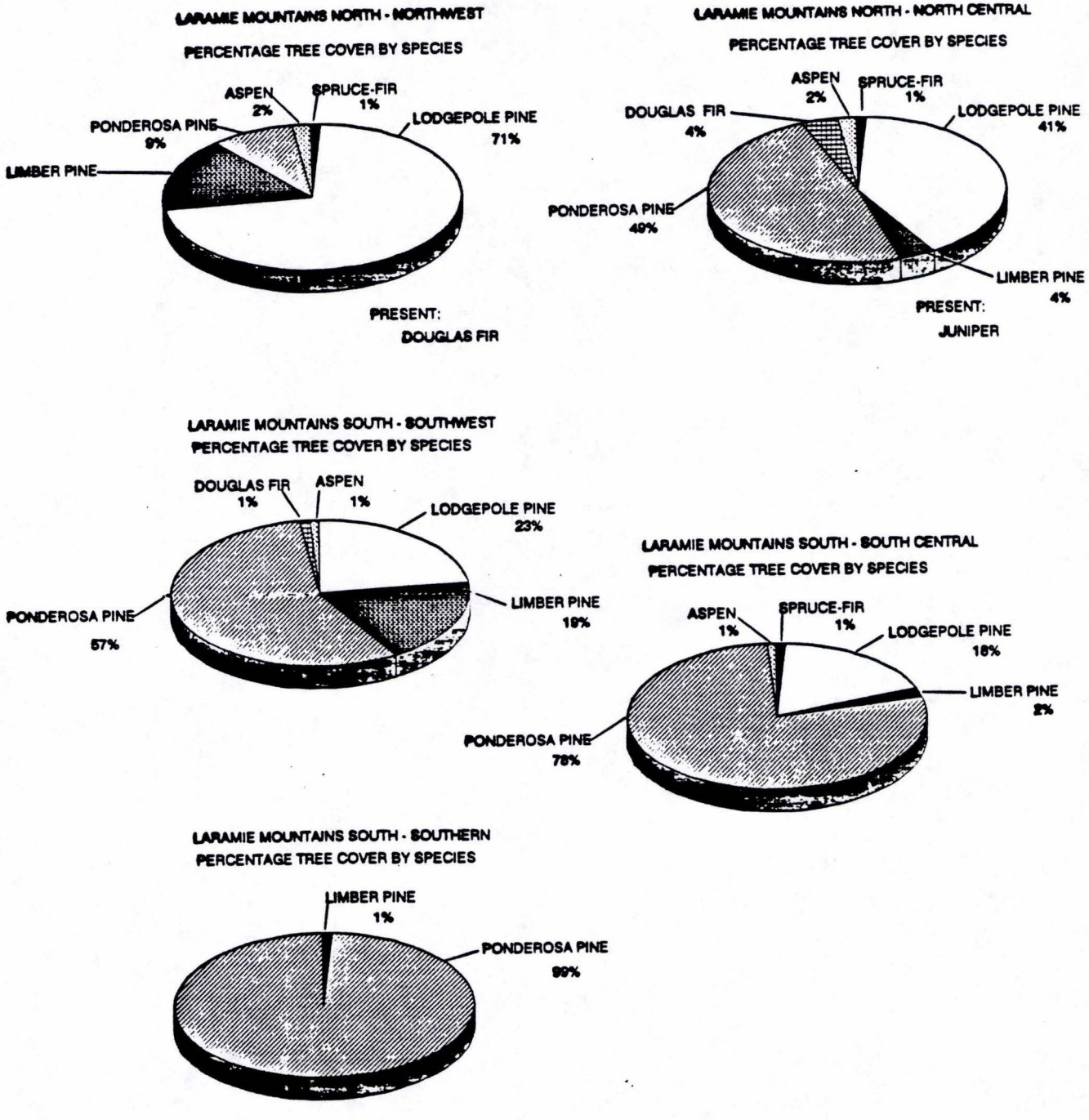


FIGURE AP11.2 Percent cover of tree species for each BDA. See Figure 6.7 for percent cover within mountain ranges. Percent cover includes all seral stages.

APPENDIX 12

ACREAGE MEASUREMENTS OF DISTURBANCE IN FORESTED ECOSYSTEMS

These tables present acreages for disturbances from clear cuts (CC), partial cuts (PC), group shelterwood cuts (GS), and fire/blowdown. Acreages for uncut forest are also presented. These are in columns by stand age categories. Table AP12.1 presents summed information for each Biodiversity Area (example SM-NW is Sierra Madre Northwest, SRN-W is Snowy Range North - west and so forth). Column codes are:

U-1550 - uncut forest with origin date before 1849.
U-1850 - uncut forest with origin date 1850-1910
U-1910 - uncut forest with origin date 1911-1949
U-1950 - uncut forest with origin date after 1950

These age categories apply to PC, GS, CC and FB categories also. Stands which are partial cut do not receive new stand origin dates, so it is possible to assess the stand age categories which have been entered for partial cuts.

These data are the basis for Figures 6.31 and 6.33.

Tables AP12.2 and AP12.3 were summed to create Table AP12.2 but AP12.2 only contains the sums for BDAs. Table AP12.2 contains information for lodgepole pine. Table AP12.3 contains information for spruce-fir.

Table AP12.4 is the acres clear cut each year by BDA (columns) used to make the graphs in Figure 6.33. Table AP12.5 is the acres partial cut each year by BDA (columns) used to make the graphs in Figure 6.33.

TABLE AP12.1 Acres of uncut forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Area (BDA). Total acres counted for the BDA are listed in the left column. From Baker (1994) Table D-1.

	BDU					
SM-NW		U-1550	U-1850	U-1910	U-1950	SUM
	SUM	8716	40220	2734	856	52526
Sierra Madre - Northwest						
		PC-1550	PC1850	PC-1910	PC-1950	SUM
	SUM	441	1581	304	476	2802
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	SUM
	SUM	0	0	0	6254	6254
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
61885	SUM	0	0	0	303	303
SM-SW		U-1550	U-1850	U-1910	U-1950	SUM
	SUM	1688	15474	2178	558	19898
Sierra Madre - Southwest						
		PC-1550	PC-1850	PC-1910	PC-1950	SUM
	SUM	27	9	11	445	492
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	SUM
	SUM	0	0	0	212	212
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
20602	SUM	0	0	0	0	0
SM-Enc. River		U-1550	U-1850	U-1910	U-1950	SUM
Sierra Madre - Encampment River	SUM	8124	18580	2674	540	29918
		PC-1550	PC-1850	PC-1910	PC-1950	SUM
	SUM	1152	674	139	527	2492
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	SUM
	SUM	0	0	0	3941	3941
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
36351	SUM	0	0	0	0	0
SM-SE		U-1550	U-1850	U-1910	U-1950	SUM
Sierra Madre - Southeast	SUM	2960	16112	1277	264	20613
		PC-1550	PC-1850	PC-1910	PC-1950	SUM
	SUM	496	425	31	2970	3922
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	0	0	0	0	0

TABLE AP12.1 Acres of uncut forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Area (BDA). Total acres counted for the BDA are listed in the left column. From Baker (1994) Table D-1.

		CC-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	0	0	0	4224	4224
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
28759	SUM	0	0	0	0	0
SRN-W		U-1550	U-1850	U-1910	U-1950	SUM
	SUM	25540	32583	5148	2032	65303
Snowy Range North - West						
		PC-1550	PC-1850	PC-1910	PC-1950	SUM
	SUM	3502	2741	1002	1445	8690
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	1852	472	48	712	3084
		CC-1550	CC-1850	CC-1910	CC-1950	SUM
	SUM	0	0	0	18452	18452
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
99004	SUM	434	161	58	2822	3475
SRN-NE		U-1550	U-1850	U-1910	U-1950	SUM
	SUM	27573	68477	4147	1500	101697
Snowy Range North - East						
		PC-1550	PC-1850	PC-1910	PC-1950	SUM
	SUM	4527	1400	551	1115	7593
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	450	15	0	408	873
		CC-1550	CC-1850	CC-1910	CC-1950	SUM
	SUM	0	0	139	13257	13396
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
125168	SUM	102	0	155	1352	1609
SRN- East Central		U-1550	U-1850	U-1910	U-1950	SUM
	SUM	16370	20372	3207	1329	41278
Snowy Range North - E. Central						
		PC-1550	PC-1850	PC-1910	PC-1950	SUM
	SUM	887	401	77	771	2136
		GS-1550	GS-1850	GS-1910	GS-1950	SUM
	SUM	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	SUM
	SUM	0	0	195	2956	3151
		FB-1550	FB-1850	FB-1910	FB-1950	SUM
46565	SUM	0	0	0	0	0

TABLE AP12.1 Acres of uncut forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Area (BDA). Total acres counted for the BDA are listed in the left column. From Baker (1994) Table D-1.

	SRS-Wilderness		U-1550	U-1850	U-1910	U-1950	SUM
Snowy Range South - Wilderness		SUM	5865	13434	874	266	20439
			PC-1550	PC-1850	PC-1910	PC-1950	SUM
		SUM	35	9	0	450	494
			GS-1550	GS-1850	GS-1910	GS-1950	SUM
		SUM	61	293	0	0	354
			CC-1550	CC-1850	CC-1910	CC-1950	SUM
		SUM				3882	3882
			FB-1550	FB-1850	FB-1910	FB-1950	SUM
	25169	SUM	0	0	0	0	0
	SRS-Cent		U-1550	U-1850	U-1910	U-1950	SUM
Snowy Range South - Central		SUM	19988	29054	5693	1015	55750
			PC-1550	PC-1850	PC-1910	PC-1950	SUM
		SUM	1548	1325	1037	1582	5492
			GS-1550	GS-1850	GS-1910	GS-1950	SUM
		SUM	0	0	0	0	0
			CC-1550	CC-1850	CC-1910	CC-1950	SUM
		SUM	0	0	0	11474	11474
			FB-1550	FB-1850	FB-1910	FB-1950	SUM
	73185	SUM	0	0	0	469	469
	SRS-SE		U-1550	U-1850	U-1910	U-1950	SUM
		SUM	2760	15155	2627	974	21516
Snowy Range South - Southeast							
			PC-1550	PC-1850	PC-1910	PC-1950	SUM
		SUM	106	351	173	581	1054
			GS-1550	GS-1850	GS-1910	GS-1950	SUM
		SUM	0	0	0	0	0
			CC-1550	CC-1850	CC-1910	CC-1950	SUM
		SUM				3892	3892
			FB-1550	FB-1850	FB-1910	FB-1950	SUM
	26462	SUM	0	0	0	0	0
	SIERRA MADRE SUM		U-1550	U-1850	U-1910	U-1950	SUM
			21488	90386	8863	2218	122955
			PC-1550	PC-1850	PC-1910	PC-1950	SUM
			2116	2689	485	4418	9708
			GS-1550	GS-1850	GS-1910	GS-1950	SUM
			0	0	0	0	0

TABLE AP12.1 Acres of uncut forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Area (BDA). Total acres counted for the BDA are listed in the left column. From Baker (1994) Table D-1.

	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	0	14631	14631
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	0	0	0	303	303
SNOWY RANGE NORTH	U-1550	U-1850	U-1910	U-1950	SUM
	69483	121432	12502	4861	208278
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	8916	4542	1630	3331	18419
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	2302	487	48	1120	3957
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	334	34665	34999
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	536	161	213	4174	5084
SNOWY RANGE SOUTH	U-1550	U-1850	U-1910	U-1950	SUM
	28613	57643	9194	2255	97705
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	1689	1685	1210	2613	7040
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	61	293	0	0	354
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	0	19248	19248
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	0	0	0	35	35
SNOWY RANGE TOTAL	U-1550	U-1850	U-1910	U-1950	SUM
	98096	179075	21696	7116	305983
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	10605	6227	2840	5944	25459
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	2363	780	48	1120	4311
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	334	53913	54247
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	536	161	213	4209	5119

TABLE AP12.1 Acres of uncut forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Area (BDA). Total acres counted for the BDA are listed in the left column. From Baker (1994) Table D-1.

LOWER BOW TOTAL	U-1550	U-1850	U-1910	U-1950	SUM
	119584	269461	30559	9334	428938
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	12721	8916	3325	10362	35167
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	2363	780	48	1120	4311
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	334	68544	68878
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	536	161	213	4512	5422

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SIERRA MADRE

SM-NW	BDU	U-1550	U-1850	U-1910	U-1950	SUM
Savery Creek	1	111	5917	330	214	6572
Dirtyman Creek	2	22	3002	4	4	3032
Big Sandstone Creek	3	1026	9831	78	81	11016
Jack Creek	13	232	6187	168	41	6628
North Spring Creek	14	1135	4262	154	57	5608
South Spring Creek	15	643	1688	12	53	2396
Cow Creek	16	638	1872	984	0	3494
	SUM	3807	32759	1730	450	38746
		PC-1550	PC-1850	PC-1910	PC-1950	
Savery Creek	1	0	0	22	70	92
Dirtyman Creek	2	0	965	0	0	965
Big Sandstone Creek	3	0	96	8	56	160
Jack Creek	13	31	23	42	41	137
North Spring Creek	14	37	270	82	57	446
South Spring Creek	15	27	41	28	53	149
Cow Creek	16	9	0	0	0	9
	SUM	104	1395	182	277	1958
		GS-1550	GS-1850	GS-1910	GS-1950	
Savery Creek	1	0	0	0	0	0
Dirtyman Creek	2	0	0	0	0	0
Big Sandstone Creek	3	0	0	0	0	0
Jack Creek	13	0	0	0	0	0
North Spring Creek	14	0	0	0	0	0
South Spring Creek	15	0	0	0	0	0
Cow Creek	16	0	0	0	0	0
	SUM	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	
Savery Creek	1	0	0	0	776	776
Dirtyman Creek	2	0	0	0	539	539
Big Sandstone Creek	3	0	0	0	571	571
Jack Creek	13	0	0	0	880	880
North Spring Creek	14	0	0	0	1730	1730
South Spring Creek	15	0	0	0	415	415
Cow Creek	16	0	0	0	443	443
	SUM	0	0	0	5354	5354
		FB-1550	FB-1850	FB-1910	FB-1950	
Savery Creek	1	0	0	0	0	0
Dirtyman Creek	2	0	0	0	0	0
Big Sandstone Creek	3	0	0	0	0	0
Jack Creek	13	0	0	0	0	0
North Spring Creek	14	0	0	0	0	0
South Spring Creek	15	0	0	0	159	159
Cow Creek	16	0	0	0	0	0
	SUM	0	0	0	159	159

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SM-SW		U-1550	U-1850	U-1910	U-1950	
Little Sandstone Creek	4	0	1095	72	0	1167
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	97	0	0	97
Lower Battle Creek	7	0	136	31	0	167
Cottonwood Creek	8	1	1	0	0	2
Roaring Fk LSR	9	62	1083	111	0	1256
N. Fk LSR	10	429	3673	284	6	4392
Upper Battle Creek	11	0	260	221	0	481
E. Fk Encampment River	12	0	983	168	0	1151
	SUM	492	7328	887	6	8713
		PC-1550	PC-1850	PC-1910	PC-1950	
Little Sandstone Creek	4	0	0	0	332	332
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	27	8	0	0	35
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	11	84	95
	SUM	27	8	11	416	462
		GS-1550	GS-1850	GS-1910	GS-1950	
Little Sandstone Creek	4	0	0	0	0	0
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	0	0
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	
Little Sandstone Creek	4	0	0	0	0	0
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	149	149
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	0	63	63
	SUM				212	212

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		FB-1550	FB-1850	FB-1910	FB-1950	
Little Sandstone Creek	4	0	0	0	0	0
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	0	0
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	0	0	0

SM-Enc. River		U-1550	U-1850	U-1910	U-1950	
N. Fk Encampment River	17	0	1376	219	0	1595
S. Fk. Miner Creek	18	12	2623	782	88	3505
Hog Park Creek	19	603	3144	449	217	4413
Encampment River Canyo	20	2232	2381	132	12	4757
Billie Creek	21	145	1104	12	34	1295
E. Fk Encampment River	22	2682	3794	217	9	6702
	SUM	5674	14422	1811	360	22267

		PC-1550	PC-1850	PC-1910	PC-1950	
N. Fk Encampment River	17	0	62	0	2	64
S. Fk. Miner Creek	18	14	67	20	67	168
Hog Park Creek	19	257	175	15	24	471
Encampment River Canyo	20	157	114	18	31	320
Billie Creek	21	158	40	0	0	198
E. Fk Encampment River	22	25	22	15	24	86
	SUM	611	480	68	148	1307

		GS-1550	GS-1850	GS-1910	GS-1950	
N. Fk Encampment River	17	0	0	0	0	0
S. Fk. Miner Creek	18	0	0	0	0	0
Hog Park Creek	19	0	0	0	0	0
Encampment River Canyo	20	0	0	0	0	0
Billie Creek	21	0	0	0	0	0
E. Fk Encampment River	22	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	
N. Fk Encampment River	17	0	0	0	93	93
S. Fk. Miner Creek	18	0	0	0	410	410
Hog Park Creek	19	0	0	0	357	357
Encampment River Canyo	20	0	0	0	1165	1165
Billie Creek	21	0	0	0	621	621
E. Fk Encampment River	22	0	0	0	757	757
	SUM	0	0	0	3403	3403

		FB-1550	FB-1850	FB-1910	FB-1950	
N. Fk Encampment River	17	0	0	0	0	0
S. Fk. Miner Creek	18	0	0	0	0	0
Hog Park Creek	19	0	0	0	0	0
Encampment River Canyo	20	0	0	0	0	0
Billie Creek	21	0	0	0	0	0
E. Fk Encampment River	22	0	0	0	0	0
	SUM	0	0	0	0	0

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SM-SE		U-1550	U-1850	U-1910	U-1950	
Beaver Creek	23	587	5399	320	38	6344
Middle Fk Big Creek	24	1657	4805	906	75	7443
Bear Creek	25	258	2952	25	0	3235
S. Fk Big Creek	26	65	2788	26	5	2884
	SUM	2567	15944	1277	118	19906
		PC-1550	PC-1850	PC-1910	PC-1950	
Beaver Creek	23	115	139	0	2410	2664
Middle Fk Big Creek	24	204	80	30	443	757
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	319	219	30	2853	3421
		GS-1550	GS-1850	GS-1910	GS-1950	
Beaver Creek	23	0	0	0	0	0
Middle Fk Big Creek	24	0	0	0	0	0
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	0	0	0	0	0
		CC-1550	GS-1850	GS-1910	GS-1950	
Beaver Creek	23	0	0	0	735	735
Middle Fk Big Creek	24	0	0	0	2660	2660
Bear Creek	25	0	0	0	79	79
S. Fk Big Creek	26	0	0	0	1	1
	SUM	0	0	0	3475	3475
		FB-1550	FB-1850	FB-1910	FB-1950	
Beaver Creek	23	0	0	0	0	0
Middle Fk Big Creek	24	0	0	0	0	0
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	0	0	0	0	0
SRN-W		U-1550	U-1850	U-1910	U-1950	
S. Fk. Lake Creek	27	102	2215	198	0	2515
N. Cedar Creek	28	227	1711	38	42	2018
Rankin Creek	29	101	2805	187	16	3109
Pass Creek	30	462	3515	87	53	4117
S. Cedar Creek	31	80	1638	68	19	1805
Lower N. Brush Creek	32	1098	2057	426	93	3674
Upper N. Brush Creek	33	131	950	317	19	1417
S. Brush Creek	34	567	713	194	118	1592
Lower Brush Creek	35	545	2485	600	292	3922
N. Cottonwood Creek	36	481	2612	58	169	3320
Middle French Creek	37	1135	597	212	100	2044
Upper S. French Creek	38	2057	861	93	54	3065
Lower S. French Creek	39	988	1476	1362	78	3904
	SUM	7974	23635	3840	1053	36502

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		PC-1550	PC-1850	PC-1910	PC-1950	
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	0	0
Rankin Creek	29	0	0	0	0	0
Pass Creek	30	0	146	13	0	159
S. Cedar Creek	31	0	0	0	0	0
Lower N. Brush Creek	32	81	16	0	190	287
Upper N. Brush Creek	33	90	55	0	12	157
S. Brush Creek	34	101	197	56	105	459
Lower Brush Creek	35	78	409	725	318	1530
N. Cottonwood Creek	36	0	0	0	32	32
Middle French Creek	37	335	230	116	195	876
Upper S. French Creek	38	51	81	0	0	132
Lower S. French Creek	39	0	23	0	149	172
	SUM	736	1157	910	1001	3804
		GS-1550	GS-1850	GS-1910	GS-1950	
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	0	0
Rankin Creek	29	0	0	0	0	0
Pass Creek	30	0	0	0	14	14
S. Cedar Creek	31	0	0	0	0	0
Lower N. Brush Creek	32	0	0	0	0	0
Upper N. Brush Creek	33	40	154	0	168	362
S. Brush Creek	34	0	0	0	4	4
Lower Brush Creek	35	0	0	0	0	0
N. Cottonwood Creek	36	0	0	0	4	4
Middle French Creek	37	39	16	0	24	79
Upper S. French Creek	38	46	0	0	4	50
Lower S. French Creek	39	0	0	0	0	0
	SUM	125	170	0	218	513
		CC-1550	CC-1850	CC-1910	CC-1950	
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	49	49
Rankin Creek	29	0	0	0	17	17
Pass Creek	30	0	0	0	1710	1710
S. Cedar Creek	31	0	0	0	417	417
Lower N. Brush Creek	32	0	0	0	1550	1550
Upper N. Brush Creek	33	0	0	0	423	423
S. Brush Creek	34	0	0	0	926	926
Lower Brush Creek	35	0	0	0	421	421
N. Cottonwood Creek	36	0	0	0	1188	1188
Middle French Creek	37	0	0	0	2561	2561
Upper S. French Creek	38	0	0	0	912	912
Lower S. French Creek	39	0	0	0	443	443
	SUM	0	0	0	10617	10617

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		FB-1550	FB-1850	FB-1910	FB-1950	
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	0	0
Rankin Creek	29	0	0	0	0	0
Pass Creek	30	0	0	0	624	624
S. Cedar Creek	31	0	0	0	0	0
Lower N. Brush Creek	32	0	0	0	146	146
Upper N. Brush Creek	33	0	0	0	0	0
S. Brush Creek	34	182	74	58	675	989
Lower Brush Creek	35	0	0	0	97	97
N. Cottonwood Creek	36	0	0	0	0	0
Middle French Creek	37	11	0	0	120	131
Upper S. French Creek	38	0	0	0	0	0
Lower S. French Creek	39	0	0	0	0	0
	SUM	193	74	58	1662	1987

SRN-NE		U-1550	U-1850	U-1910	U-1950	
Fourmile Creek	60	4523	1826	530	215	7094
North Rock Creek	61	2187	56995	795	55	60032
South Rock Creek	62	4319	292	453	68	5132
W. Medicine Bow R	63	964	1249	179	218	2610
Upper Medicine Bow River	64	62	0	0	0	62
Lower Medicine Bow River	65	446	902	1199	72	2619
East Medicine Bow River	66	307	1643	104	137	2191
Wagonhound Creek	67	377	2496	47	108	3028
	SUM	13185	65403	3307	873	82768

		PC-1550	PC-1850	PC-1910	PC-1950	
Fourmile Creek	60	122	0	0	127	249
North Rock Creek	61	32	27	0	96	155
South Rock Creek	62	324	0	0	0	324
W. Medicine Bow R	63	31	39	0	38	108
Upper Medicine Bow River	64	0	0	0	0	0
Lower Medicine Bow River	65	86	103	134	87	410
East Medicine Bow River	66	168	58	27	195	448
Wagonhound Creek	67	39	436	362	272	1109
	SUM	802	663	523	815	2803

		GS-1550	GS-1850	GS-1910	GS-1950	
Fourmile Creek	60	0	0	0	0	0
North Rock Creek	61	0	0	0	0	0
South Rock Creek	62	0	0	0	0	0
W. Medicine Bow R	63	0	0	0	141	141
Upper Medicine Bow River	64	0	0	0	0	0
Lower Medicine Bow River	65	0	0	0	4	4
East Medicine Bow River	66	28	0	0	44	72
Wagonhound Creek	67	0	12	0	0	12
	SUM	28	12	0	189	229

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		CC-1550	CC-1850	CC-1910	CC-1950	
Fourmile Creek	60	0	0	0	529	529
North Rock Creek	61	0	0	0	1086	1086
South Rock Creek	62	0	0	0	1908	1908
W. Medicine Bow R	63	0	0	0	928	928
Upper Medicine Bow River	64	0	0	0	0	0
Lower Medicine Bow River	65	0	0	0	774	774
East Medicine Bow River	66	0	0	0	1331	1331
Wagonhound Creek	67	0	0	0	1013	1013
	SUM	0	0	0	7569	7569

		FB-1550	FB-1850	FB-1910	FB-1950	
Fourmile Creek	60	0	0	0	0	0
North Rock Creek	61	0	0	0	951	951
South Rock Creek	62	0	0	0	0	0
W. Medicine Bow R	63	0	0	0	123	123
Upper Medicine Bow River	64	0	0	0	0	0
Lower Medicine Bow River	65	0	0	0	0	0
East Medicine Bow River	66	0	0	0	0	0
Wagonhound Creek	67	0	0	0	0	0
	SUM	0	0	0	1074	1074

SRN- East Central		U-1550	U-1850	U-1910	U-1950	
South Fork	56	2103	2866	480	33	5482
Middle Fork	57	3717	5158	367	275	9517
North Fork	58	1904	6469	1087	292	9752
Mill Creek	59	869	1796	187	16	2868
	SUM	8593	16289	2121	616	27619

		PC-1550	PC-1850	PC-1910	PC-1950	
South Fork	56	41	28	71	52	192
Middle Fork	57	258	139	0	353	750
North Fork	58	250	24	3	304	581
Mill Creek	59	25	18	0	0	43
	SUM	574	209	74	709	1566

		GS-1550	GS-1850	GS-1910	GS-1950	
South Fork	56	0	0	0	0	0
Middle Fork	57	0	0	0	0	0
North Fork	58	0	0	0	0	0
Mill Creek	59	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	
South Fork	56	0	0	0	339	339
Middle Fork	57	0	0	80	1296	1376
North Fork	58	0	0	44	445	489
Mill Creek	59	0	0	0	602	602
	SUM	0	0	124	2682	2806

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		FB-1550	FB-1850	FB-1910	FB-1950	
South Fork	56	0	0	0	0	0
Middle Fork	57	0	0	0	0	0
North Fork	58	0	0	0	0	0
Mill Creek	59	0	0	0	0	0
	SUM	0	0	0	0	0
SRS-Wilderness		U-1550	U-1850	U-1910	U-1950	
Mullen Creek	40	1212	3139	124	136	4611
Cottonwood Creek	41	1217	848	37	75	2177
Platte River	42	1481	6688	672	39	8880
	SUM	3910	10675	833	250	15668
		PC-1550	PC-1850	PC-1910	PC-1950	
Mullen Creek	40	14	0	0	448	462
Cottonwood Creek	41	0	0	0	0	0
Platte River	42	0	0	0	0	0
	SUM	18	0	0	448	466
		GS-1550	GS-1850	GS-1910	GS-1950	
Mullen Creek	40	0	0	0	0	0
Cottonwood Creek	41	0	0	0	0	0
Platte River	42	0	0	0	0	0
	SUM	0	0	0	0	0
		CC-1550	CC-1850	CC-1910	CC-1950	
Mullen Creek	40	0	0	0	1489	1489
Cottonwood Creek	41	0	0	0	699	699
Platte River	42	0	0	0	1405	1405
	SUM	0	0	0	3593	3593
		FB-1550	FB-1850	FB-1910	FB-1950	
Mullen Creek	40	0	0	0	0	0
Cottonwood Creek	41	0	0	0	0	0
Platte River	42	0	0	0	0	0
	SUM	0	0	0	0	0
SRS-Cent		U-1550	U-1850	U-1910	U-1950	
Pelton Creek	43	1761	9020	3128	202	14111
Lower Douglas Creek	44	1347	7828	364	0	9539
Mowberg Creek	45	1314	2005	131	121	3571
Lake Creek	46	1466	2606	862	98	5032
Muddly Creek	47	2542	901	349	37	3829
Middle Douglas Creek	48	4278	1159	217	30	5684
Devils Gate Creek	49	907	3559	216	9	4691
Upper Douglas Creek	50	2347	797	253	424	3821
	SUM	15962	27875	5520	921	50278
		PC-1550	PC-1850	PC-1910	PC-1950	
Pelton Creek	43	0	106	79	274	459
Lower Douglas Creek	44	7	0	0	46	53
Mowberg Creek	45	20	449	3	67	539
Lake Creek	46	374	421	707	682	2184
Muddly Creek	47	61	56	83	103	303
Middle Douglas Creek	48	13	101	24	219	357
Devils Gate Creek	49	0	0	0	0	0
Upper Douglas Creek	50	487	17	33	108	645
	SUM	962	1150	929	1499	4540

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		GS-1550	GS-1850	GS-1910	GS-1950	
Pelton Creek	43	0	0	0	0	0
Lower Douglas Creek	44	0	0	0	0	0
Mowberg Creek	45	0	0	0	0	0
Lake Creek	46	0	0	0	0	0
Muddly Creek	47	0	0	0	0	0
Middle Douglas Creek	48	0	0	0	0	0
Devils Gate Creek	49	0	0	0	0	0
Upper Douglas Creek	50	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	
Pelton Creek	43	0	0	0	1859	1859
Lower Douglas Creek	44	0	0	0	641	641
Mowberg Creek	45	0	0	0	1055	1055
Lake Creek	46	0	0	0	1303	1303
Muddly Creek	47	0	0	0	960	960
Middle Douglas Creek	48	0	0	0	1420	1420
Devils Gate Creek	49	0	0	0	1282	1282
Upper Douglas Creek	50	0	0	0	2459	2459
	SUM	0	0	0	10979	10979

		FB-1550	FB-1850	FB-1910	FB-1950	
Pelton Creek	43	0	0	0	0	0
Lower Douglas Creek	44	0	0	0	0	0
Mowberg Creek	45	0	0	0	118	118
Lake Creek	46	0	0	0	0	0
Muddly Creek	47	0	0	0	32	32
Middle Douglas Creek	48	0	0	0	284	284
Devils Gate Creek	49	0	0	0	0	0
Upper Douglas Creek	50	0	0	0	35	35
	SUM	0	0	0	469	469

SRS-SE		U-1550	U-1850	U-1910	U-1950	
Boswell Creek	51	957	2887	1199	349	5392
Bear Creek	52	748	4878	522	279	6427
Lake Owen Creek	53	828	6912	884	324	8948
Johns Creek	54	ShMtn	nd	nd	nd	0
Buckeye Creek	55	ShMtn	nd	nd	nd	0
	SUM	2533	14677	2605	952	20767

		PC-1550	PC-1850	PC-1910	PC-1950	
Boswell Creek	51	19	20	0	222	261
Bear Creek	52	0	39	20	207	266
Lake Owen Creek	53	74	148	153	152	527
Johns Creek	54	ShMtn	nd	nd	nd	0
Buckeye Creek	55	ShMtn	nd	nd	nd	0
	SUM	93	207	173	581	1054

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		GS-1550	GS-1850	GS-1910	GS-1950	
Boswell Creek	51	0	0	0	0	0
Bear Creek	52	0	0	0	0	0
Lake Owen Creek	53	0	0	0	0	0
Johns Creek	54	0	0	0	0	0
Buckeye Creek	55	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	
Boswell Creek	51	0	0	0	956	956
Bear Creek	52	0	0	0	1505	1505
Lake Owen Creek	53	0	0	0	1411	1411
Johns Creek	54	0	0	0	0	0
Buckeye Creek	55	0	0	0	0	0
	SUM	0	0	0	3872	3872

		FB-1550	FB-1850	FB-1910	FB-1950	
Boswell Creek	51	0	0	0	0	0
Bear Creek	52	0	0	0	0	0
Lake Owen Creek	53	0	0	0	0	0
Johns Creek	54	0	0	0	0	0
Buckeye Creek	55	0	0	0	0	0
	SUM	0	0	0	0	0

SIERRA MADRE SUM	U-1550	U-1850	U-1910	U-1950	SUM
	12540	70453	5705	934	89632
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	1061	2102	291	3694	7148
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	0	0	0	0	0
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	0	12444	12444
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	0	0	0	159	159

SNOWY RANGE NORTH	U-1550	U-1850	U-1910	U-1950	SUM
	29752	105327	9268	2542	146889
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	2112	2029	1507	2525	8173
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	153	182	0	407	742
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	124	20868	20992
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	193	74	58	2736	3061

TABLE AP12.2 Acres of uncut lodgepole pine forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SNOWY RANGE SOUTH	U-1550	U-1850	U-1910	U-1950	SUM
	22405	53227	8958	2123	86713
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	1073	1357	1102	2528	6060
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	0	0	0	0	0
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	0	18444	18444
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	0	0	0	35	35
SNOWY RANGE TOTAL	U-1550	U-1850	U-1910	U-1950	SUM
	52157	158554	18226	4665	233602
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	3185	3386	2609	5053	14233
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	153	182	0	407	742
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	124	39312	39436
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	193	74	58	2771	3096
LOWER BOW TOTAL	U-1550	U-1850	U-1910	U-1950	SUM
	64697	229007	23931	5599	323234
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	4246	5488	2900	8747	21381
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	153	182	0	407	742
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	124	51756	51880
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	193	74	58	2930	3255

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SM-NW	BDU	U-1550	U-1850	U-1910	U-1950	SUM
Savery Creek	1	74	1322	0	10	1406
Dirtyman Creek	2	0	125	0	15	140
Big Sandstone Creek	3	260	1582	253	106	2201
Jack Creek	13	1144	863	0	25	2032
North Spring Creek	14	1192	494	18	52	1756
South Spring Creek	15	1687	1270	100	68	3125
Cow Creek	16	552	1805	633	130	3120
	SUM	4909	7461	1004	406	13780

		PC-1550	PC1850	PC-1910	PC-1950	SUM
Savery Creek	1	0	0	0	0	0
Dirtyman Creek	2	0	0	0	0	0
Big Sandstone Creek	3	0	0	0	0	0
Jack Creek	13	0	10	31	14	55
North Spring Creek	14	1	0	63	41	105
South Spring Creek	15	280	89	0	3	372
Cow Creek	16	56	87	28	141	312
	SUM	337	186	122	199	844

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Savery Creek	1	0	0	0	0	0
Dirtyman Creek	2	0	0	0	0	0
Big Sandstone Creek	3	0	0	0	0	0
Jack Creek	13	0	0	0	0	0
North Spring Creek	14	0	0	0	0	0
South Spring Creek	15	0	0	0	0	0
Cow Creek	16	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
Savery Creek	1	0	0	0	12	12
Dirtyman Creek	2	0	0	0	0	0
Big Sandstone Creek	3	0	0	0	0	0
Jack Creek	13	0	0	0	120	120
North Spring Creek	14	0	0	0	138	138
South Spring Creek	15	0	0	0	493	493
Cow Creek	16	0	0	0	137	137
	SUM	0	0	0	900	900

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Savery Creek	1	0	0	0	0	0
Dirtyman Creek	2	0	0	0	0	0
Big Sandstone Creek	3	0	0	0	0	0
Jack Creek	13	0	0	0	0	0
North Spring Creek	14	0	0	0	0	0
South Spring Creek	15	0	0	0	144	144
Cow Creek	16	0	0	0	0	0
	SUM	0	0	0	144	144

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SM-SW		U-1550	U-1850	U-1910	U-1950	SUM
Little Sandstone Creek	4	0	39	0	0	39
Big Gulch	5	0	116	0	0	116
E. Sweetwater Gulch	6	0	8	21	0	29
Lower Battle Creek	7	0	2	0	0	2
Cottonwood Creek	8	0	14	0	0	14
Roaring Fk LSR	9	399	903	0	0	1302
N. Fk LSR	10	698	4181	731	471	6081
Upper Battle Creek	11	44	1792	191	0	2027
E. Fk Encampment River	12	55	1091	348	81	1575
	SUM	1196	8146	1291	552	11185

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
Little Sandstone Creek	4	0	0	0	29	29
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	0	0
Upper Battle Creek	11	0	1	0	0	1
E. Fk Encampment River	12	0	0	0	0	0
	SUM	0	1	0	29	30

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Little Sandstone Creek	4	0	0	0	0	0
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	0	0
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
Little Sandstone Creek	4	0	0	0	0	0
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	0	0
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	0	0	0
	SUM	0	0	0	0	0

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Little Sandstone Creek	4	0	0	0	0	0
Big Gulch	5	0	0	0	0	0
E. Sweetwater Gulch	6	0	0	0	0	0
Lower Battle Creek	7	0	0	0	0	0
Cottonwood Creek	8	0	0	0	0	0
Roaring Fk LSR	9	0	0	0	0	0
N. Fk LSR	10	0	0	0	0	0
Upper Battle Creek	11	0	0	0	0	0
E. Fk Encampment River	12	0	0	0	0	0
	SUM	0	0	0	0	0

SM-Enc. River		U-1550	U-1850	U-1910	U-1950	SUM
N. Fk Encampment River	17	353	393	344	65	1155
S. Fk. Miner Creek	18	300	1024	335	98	1757
Hog Park Creek	19	219	662	168	1	1050
Encampment River Canyo	20	240	250	9	9	508
Billie Creek	21	7	837	0	5	849
E. Fk Encampment River	22	1331	992	7	2	2332
	SUM	2450	4158	863	180	7651

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
N. Fk Encampment River	17	488	0	54	3	545
S. Fk. Miner Creek	18	53	81	0	345	479
Hog Park Creek	19	0	0	0	0	0
Encampment River Canyo	20	0	77	0	0	77
Billie Creek	21	0	0	11	0	11
E. Fk Encampment River	22	0	36	6	31	73
	SUM	541	194	71	379	1185

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
N. Fk Encampment River	17	0	0	0	0	0
S. Fk. Miner Creek	18	0	0	0	0	0
Hog Park Creek	19	0	0	0	0	0
Encampment River Canyo	20	0	0	0	0	0
Billie Creek	21	0	0	0	0	0
E. Fk Encampment River	22	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
N. Fk Encampment River	17	0	0	0	48	48
S. Fk. Miner Creek	18	0	0	0	100	100
Hog Park Creek	19	0	0	0	24	24
Encampment River Canyo	20	0	0	0	51	51
Billie Creek	21	0	0	0	0	0
E. Fk Encampment River	22	0	0	0	315	315
	SUM	0	0	0	538	538

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
N. Fk Encampment River	17	0	0	0	0	0
S. Fk. Miner Creek	18	0	0	0	0	0
Hog Park Creek	19	0	0	0	0	0
Encampment River Canyo	20	0	0	0	0	0
Billie Creek	21	0	0	0	0	0
E. Fk Encampment River	22	0	0	0	0	0
	SUM	0	0	0	0	0

SM-SE		U-1550	U-1850	U-1910	U-1950	SUM
Beaver Creek	23	44	86	0	121	251
Middle Fk Big Creek	24	349	82	0	25	456
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	393	168	0	146	707

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
Beaver Creek	23	169	119	1	17	306
Middle Fk Big Creek	24	8	87	0	100	195
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	177	206	1	117	501

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Beaver Creek	23	0	0	0	0	0
Middle Fk Big Creek	24	0	0	0	0	0
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	GS-1850	GS-1910	GS-1950	SUM
Beaver Creek	23	0	0	0	140	140
Middle Fk Big Creek	24	0	0	0	609	609
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	0	0	0	749	749

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Beaver Creek	23	0	0	0	0	0
Middle Fk Big Creek	24	0	0	0	0	0
Bear Creek	25	0	0	0	0	0
S. Fk Big Creek	26	0	0	0	0	0
	SUM	0	0	0	0	0

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

SRN-W		U-1550	U-1850	U-1910	U-1950	SUM
S. Fk. Lake Creek	27	444	282	96	0	822
N. Cedar Creek	28	350	717	33	0	1100
Rankin Creek	29	1107	280	236	3	1626
Pass Creek	30	3218	328	65	46	3657
S. Cedar Creek	31	542	1184	25	339	2090
Lower N. Brush Creek	32	881	450	20	181	1532
Upper N. Brush Creek	33	2870	1626	377	26	4899
S. Brush Creek	34	3838	568	84	215	4705
Lower Brush Creek	35	166	337	203	20	726
N. Cottonwood Creek	36	0	51	11	0	62
Middle French Creek	37	1584	672	100	93	2449
Upper S. French Creek	38	2307	2175	58	45	4585
Lower S. French Creek	39	259	278	0	11	548
	SUM	17566	8948	1308	979	28801

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	0	0
Rankin Creek	29	0	0	0	0	0
Pass Creek	30	0	22	0	9	31
S. Cedar Creek	31	0	0	0	47	47
Lower N. Brush Creek	32	193	31	29	10	263
Upper N. Brush Creek	33	310	142	0	4	456
S. Brush Creek	34	1329	496	0	67	1892
Lower Brush Creek	35	63	241	52	234	590
N. Cottonwood Creek	36	0	0	0	0	0
Middle French Creek	37	790	336	11	30	1167
Upper S. French Creek	38	81	304	0	10	395
Lower S. French Creek	39	0	12	0	33	45
	SUM	2766	1584	92	444	4886

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	0	0
Rankin Creek	29	0	0	0	0	0
Pass Creek	30	416	19	14	118	567
S. Cedar Creek	31	0	0	0	13	13
Lower N. Brush Creek	32	0	0	0	0	0
Upper N. Brush Creek	33	577	244	34	131	986
S. Brush Creek	34	0	0	0	0	0
Lower Brush Creek	35	0	0	0	0	0
N. Cottonwood Creek	36	0	0	0	0	0
Middle French Creek	37	349	26	0	187	562
Upper S. French Creek	38	365	13	0	45	423
Lower S. French Creek	39	20	0	0	0	20
	SUM	1727	302	48	494	2571

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	58	58
Rankin Creek	29	0	0	0	82	82
Pass Creek	30	0	0	0	1314	1314
S. Cedar Creek	31	0	0	0	167	167
Lower N. Brush Creek	32	0	0	0	1246	1246
Upper N. Brush Creek	33	0	0	0	1674	1674
S. Brush Creek	34	0	0	0	312	312
Lower Brush Creek	35	0	0	0	28	28
N. Cottonwood Creek	36	0	0	0	34	34
Middle French Creek	37	0	0	0	1504	1504
Upper S. French Creek	38	0	0	0	1285	1285
Lower S. French Creek	39	0	0	0	131	131
	SUM	0	0	0	7835	7835

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
S. Fk. Lake Creek	27	0	0	0	0	0
N. Cedar Creek	28	0	0	0	0	0
Rankin Creek	29	0	0	0	0	0
Pass Creek	30	0	0	0	132	132
S. Cedar Creek	31	0	0	0	0	0
Lower N. Brush Creek	32	0	0	0	612	612
Upper N. Brush Creek	33	22	0	0	15	37
S. Brush Creek	34	179	43	0	46	268
Lower Brush Creek	35	37	44	0	85	166
N. Cottonwood Creek	36	0	0	0	0	0
Middle French Creek	37	3	0	0	270	273
Upper S. French Creek	38	0	0	0	0	0
Lower S. French Creek	39	0	0	0	0	0
	SUM	241	87	0	1160	1488

SRN-NE		U-1550	U-1850	U-1910	U-1950	SUM
Fourmile Creek	60	828	81	0	51	960
North Rock Creek	61	4006	720	482	71	5279
South Rock Creek	62	3958	642	68	13	4681
W. Medicine Bow R	63	1199	156	0	162	1517
Upper Medicine Bow River	64	2134	378	3	45	2560
Lower Medicine Bow River	65	1258	603	82	75	2018
East Medicine Bow River	66	985	104	205	64	1358
Wagonhound Creek	67	20	390	0	146	556
	SUM	14388	3074	840	627	18929

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
Fourmile Creek	60	12	31	0	36	79
North Rock Creek	61	935	123	5	27	1090
South Rock Creek	62	1910	9	0	0	1919
W. Medicine Bow R	63	66	59	2	33	160
Upper Medicine Bow River	64	0	0	0	32	32
Lower Medicine Bow River	65	69	100	17	39	225
East Medicine Bow River	66	733	116	4	38	891
Wagonhound Creek	67	0	299	0	95	394
	SUM	3725	737	28	300	4790

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Fourmile Creek	60	0	0	0	0	0
North Rock Creek	61	46	2	0	48	96
South Rock Creek	62	0	0	0	0	0
W. Medicine Bow R	63	0	0	0	93	93
Upper Medicine Bow River	64	0	0	0	0	0
Lower Medicine Bow River	65	0	0	0	0	0
East Medicine Bow River	66	370	1	0	78	449
Wagonhound Creek	67	6	0	0	0	6
	SUM	422	3	0	219	644

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
Fourmile Creek	60	0	0	0	48	48
North Rock Creek	61	0	0	139	1351	1490
South Rock Creek	62	0	0	0	606	606
W. Medicine Bow R	63	0	0	0	1102	1102
Upper Medicine Bow River	64	0	0	0	230	230
Lower Medicine Bow River	65	0	0	0	833	833
East Medicine Bow River	66	0	0	0	1477	1477
Wagonhound Creek	67	0	0	0	41	41
	SUM	0	0	139	5688	5827

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Fourmile Creek	60	0	0	0	0	0
North Rock Creek	61	0	0	0	0	0
South Rock Creek	62	0	0	0	0	0
W. Medicine Bow R	63	102	0	155	13	270
Upper Medicine Bow River	64	0	0	0	0	0
Lower Medicine Bow River	65	0	0	0	246	246
East Medicine Bow River	66	0	0	0	0	0
Wagonhound Creek	67	0	0	0	19	19
	SUM	102	0	155	278	535

SRN- East Central		U-1550	U-1850	U-1910	U-1950	SUM
South Fork	56	260	63	27	15	365
Middle Fork	57	1654	1745	402	185	3986
North Fork	58	5364	2134	657	504	8659
Mill Creek	59	499	141	0	9	649
	SUM	7777	4083	1086	713	13659

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
South Fork	56	0	103	0	0	103
Middle Fork	57	141	51	0	0	192
North Fork	58	165	38	3	62	268
Mill Creek	59	7	0	0	0	7
	SUM	313	192	3	62	570

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
South Fork	56	0	0	0	0	0
Middle Fork	57	0	0	0	0	0
North Fork	58	0	0	0	0	0
Mill Creek	59	0	0	0	0	0
	SUM	0	0	0	0	0

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
South Fork	56	0	0	0	19	19
Middle Fork	57	0	0	0	107	107
North Fork	58	0	0	71	85	156
Mill Creek	59	0	0	0	63	63
	SUM	0	0	71	274	345

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
South Fork	56	0	0	0	0	0
Middle Fork	57	0	0	0	0	0
North Fork	58	0	0	0	0	0
Mill Creek	59	0	0	0	0	0
	SUM	0	0	0	0	0

SRS-Wilderness		U-1550	U-1850	U-1910	U-1950	SUM
Mullen Creek	40	1675	2626	37	3	4341
Cottonwood Creek	41	258	70	4	0	332
Platte River	42	22	63	0	13	98
	SUM	1955	2759	41	16	4771

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
Mullen Creek	40	0	7	0	2	9
Cottonwood Creek	41	12	0	0	0	12
Platte River	42	0	0	0	0	0
	SUM	17	9	0	2	28

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Mullen Creek	40	46	221	0	0	267
Cottonwood Creek	41	0	0	0	0	0
Platte River	42	0	0	0	0	0
	SUM	61	293	0	0	354

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
Mullen Creek	40	0	0	0	269	269
Cottonwood Creek	41	0	0	0	20	20
Platte River	42	0	0	0	0	0
	SUM	0	0	0	289	289

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Mullen Creek	40	0	0	0	0	0
Cottonwood Creek	41	0	0	0	0	0
Platte River	42	0	0	0	0	0
	SUM	0	0	0	0	0

SRS-Cent		U-1550	U-1850	U-1910	U-1950	SUM
Pelton Creek	43	238	302	106	9	655
Lower Douglas Creek	44	67	45	0	0	112
Mowberg Creek	45	83	15	0	20	118
Lake Creek	46	110	171	0	0	281
Muddy Creek	47	285	0	0	0	285
Middle Douglas Creek	48	1314	288	49	13	1664
Devils Gate Creek	49	228	20	1	17	266
Upper Douglas Creek	50	1701	338	17	35	2091
	SUM	4026	1179	173	94	5472

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
Pelton Creek	43	0	6	0	0	6
Lower Douglas Creek	44	0	0	0	0	0
Mowberg Creek	45	0	15	0	0	15
Lake Creek	46	9	64	0	0	73
Muddly Creek	47	0	2	0	0	2
Middle Douglas Creek	48	202	55	108	45	410
Devils Gate Creek	49	0	0	0	0	0
Upper Douglas Creek	50	375	33	0	38	446
	SUM	586	175	108	83	952

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Pelton Creek	43	0	0	0	0	0
Lower Douglas Creek	44	0	0	0	0	0
Mowberg Creek	45	0	0	0	0	0
Lake Creek	46	0	0	0	0	0
Muddly Creek	47	0	0	0	0	0
Middle Douglas Creek	48	0	0	0	0	0
Devils Gate Creek	49	0	0	0	0	0
Upper Douglas Creek	50	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
Pelton Creek	43	0	0	0	87	87
Lower Douglas Creek	44	0	0	0	14	14
Mowberg Creek	45	0	0	0	13	13
Lake Creek	46	0	0	0	0	0
Muddy Creek	47	0	0	0	1	1
Middle Douglas Creek	48	0	0	0	73	73
Devils Gate Creek	49	0	0	0	8	8
Upper Douglas Creek	50	0	0	0	299	299
	SUM	0	0	0	495	495

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Pelton Creek	43	0	0	0	0	0
Lower Douglas Creek	44	0	0	0	0	0
Mowberg Creek	45	0	0	0	0	0
Lake Creek	46	0	0	0	0	0
Muddy Creek	47	0	0	0	0	0
Middle Douglas Creek	48	0	0	0	0	0
Devils Gate Creek	49	0	0	0	0	0
Upper Douglas Creek	50	0	0	0	0	0
	SUM	0	0	0	0	0

SRS-SE		U-1550	U-1850	U-1910	U-1950	SUM
Boswell Creek	51	92	169	17	0	278
Bear Creek	52	44	50	5	0	99
Lake Owen Creek	53	91	259	0	22	372
Johns Creek	54	ShMtn	nd	nd	nd	0
Buckeye Creek	55	ShMtn	nd	nd	nd	0
	SUM	227	478	22	22	749

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

		PC-1550	PC-1850	PC-1910	PC-1950	SUM
Boswell Creek	51	0	0	0	0	0
Bear Creek	52	0	0	0	0	0
Lake Owen Creek	53	13	144	0	0	0
Johns Creek	54	ShMtn	nd	nd	nd	0
Buckeye Creek	55	ShMtn	nd	nd	nd	0
	SUM	13	144	0	0	0

		GS-1550	GS-1850	GS-1910	GS-1950	SUM
Boswell Creek	51	0	0	0	0	0
Bear Creek	52	0	0	0	0	0
Lake Owen Creek	53	0	0	0	0	0
Johns Creek	54	0	0	0	0	0
Buckeye Creek	55	0	0	0	0	0
	SUM	0	0	0	0	0

		CC-1550	CC-1850	CC-1910	CC-1950	SUM
Boswell Creek	51	0	0	0	0	0
Bear Creek	52	0	0	0	11	11
Lake Owen Creek	53	0	0	0	9	9
Johns Creek	54	0	0	0	0	0
Buckeye Creek	55	0	0	0	0	0
	SUM	0	0		20	20

		FB-1550	FB-1850	FB-1910	FB-1950	SUM
Boswell Creek	51	0	0	0	0	0
Bear Creek	52	0	0	0	0	0
Lake Owen Creek	53	0	0	0	0	0
Johns Creek	54	0	0	0	0	0
Buckeye Creek	55	0	0	0	0	0
	SUM	0	0	0	0	0

SIERRA MADRE SUM	U-1550	U-1850	U-1910	U-1950	SUM
	8948	19933	3158	1284	33323
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	1055	587	194	724	2560
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	0	0	0	0	0
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	0	2187	2187
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	0	0	0	144	144

SNOWY RANGE NORTH	U-1550	U-1850	U-1910	U-1950	SUM
	39731	16105	3234	2319	61389
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	6804	2513	123	806	10246
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	2149	305	48	713	3215

TABLE AP12.3 Acres of uncut spruce-fir forest in age categories, and acres of partial cuts (PC), group shelterwood (GS), clear cuts (CC) and fire/blowdown (FB) for each Biodiversity Analysis Unit (BDU). From Baker (1994) Table D-1.

	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	210	13797	14007
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	343	87	155	1438	2023
SNOWY RANGE SOUTH	U-1550	U-1850	U-1910	U-1950	SUM
	6208	4416	236	132	10992
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	616	328	108	85	980
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	61	293	0	0	354
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	0	804	804
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	0	0	0	0	0
SNOWY RANGE TOTAL	U-1550	U-1850	U-1910	U-1950	SUM
	45939	20521	3470	2451	72381
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	7420	2841	231	891	11226
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	2210	598	48	713	3569
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	210	14601	14811
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	343	87	155	1438	2023
LOWER BOW TOTAL	U-1550	U-1850	U-1910	U-1950	SUM
	54887	40454	6628	3735	105704
	PC-1550	PC-1850	PC-1910	PC-1950	SUM
	8475	3428	425	1615	13786
	GS-1550	GS-1850	GS-1910	GS-1950	SUM
	2210	598	48	713	3569
	CC-1550	CC-1850	CC-1910	CC-1950	SUM
	0	0	210	16788	16998
	FB-1550	FB-1850	FB-1910	FB-1950	SUM
	343	87	155	1582	2167

TABLE AP12.4 Acres clear cut each year for each Biodiversity Analysis Area. From GIS - C. Tolbert. See Figure 6.33.

	SRN-W	SRN-E	SNR-EC	SRS-W	SRS-C	SRS-SE	SUM
			183				
1951	503	3				267	773
52	60						60
53	151						151
54	41	3					44
55	2373	472	30			26	2901
56	95	1016			132		1243
57	1760	756			29	528	3073
58	5	2010	16				2031
59	811	1345	35		170		2361
1960	957	822	47		573		2399
61	931	178	68		443		1620
62	525	59	4		31	19	638
63	794		57				851
64	1181	266	72	15	708	197	2439
65	454	310	118	22	184	188	1276
66	132	233	68	134	1098	556	2221
67	955	46	28	3	715	108	1855
68	449	79	31		219		778
69	888	171	187	187	557		1990
1970	339	537	222	88	874	41	2101
71	909	859	16	577	124	43	2528
72	348	227	98	392	771	164	2000
73	176	329	203		49		757
74	579	452		440	343		1814
75	28	131	25	163	23		370
76	32	291	87	249	151	128	938
77	61		75	107	121		364
78	25	29	54	107	119	138	472
79	76		18		199	19	312
1980	121		22		452	88	683
81	248				216	192	656
82	277	81			192	35	585
83	647	49	6	21	240	30	993
84	93	106	217	20	348	3	787
85	558	400	42	18	336		1354
86	283	612	319	38	120		1372
87	239	963	18	92	438	3	1753
88	373	392	37	18			820
89		384		464	346	122	1316
1990		8	104	102	31	44	289
91	213	110	209	106	48	340	1026
92	197	25	128	121	809	231	1511
93	4	7	11	233	161	331	747
94	100			131			231
12690	18991	13761	2672	3850	11370	3841	54485

TABLE AP12.4 Acres clear cut each year for each Biodiversity Analysis Area. From GIS - C. Tolbert. See Figure 6.33.

	SMNW	SMSW	ENCR	SMSE	SUM
1950					
51					0
52					0
53					0
54	20			333	353
55			12	212	224
56					0
57				37	37
58	93				93
59					0
1960				179	179
61				209	209
62	274			130	404
63	52		3	69	124
64			67	458	525
65	82		62	193	337
66				281	281
67			103	331	434
68	127			271	398
69			32	3	35
1970			78	74	152
71			261		261
72			489	8	497
73	50		263		313
74	110		263	5	378
75	182		123		305
76	542		224	6	772
77	213		74	5	292
78	325	248	64	85	722
79	543	8		33	584
1980	236		1	35	272
81	72		69	80	221
82	90	510	57	92	749
83	170	40	4	193	407
84	208		7	7	222
85	268	29		75	372
86	360	28	8	30	426
87	471	11	17	121	620
88	685	8	3	79	775
89	261	184	543	56	1044
1990	651	77	36	144	908
91	167	124	451	401	1143
92			849		849
93		116	196		312
94		370		69	439
SUM	6252	1753	4359	4304	16668

TABLE AP12.5 Acres partial cut each year for each Biodiversity Analysis Area. From GIS - C. Tolbert. See Figure 6.33.

	SMNW	SMSW	SMER	SMSE	0
1950					0
51					0
52					0
53					0
54					0
55			64		64
56					0
57					0
58					0
59					0
1960					0
61					0
62					0
63					0
64					0
65					0
66			90		90
67					0
68					0
69					0
1970					0
71					0
72					0
73					0
74	66		544	1	611
75	361		25		386
76	547		36		583
77	3		3	33	39
78	13		110	27	150
79	228			153	381
1980	368		221	35	624
81	351		292	175	818
82	117		148	217	482
83	88		18	671	777
84	368		13	111	492
85	279		400	632	1311
86	86	130		80	296
87	442	103	59	608	1212
88	975	92	145	13	1225
89	62	525	543	30	1160
1990	421	299	28	8	756
91	167	198	1096	37	1498
92			224		224
93		33	130		163
94		370		29	399
SUM	4942	1750	4189	2860	13741

TABLE AP12.5 Acres partial cut each year for each Biodiversity Analysis Area. From GIS - C. Tolbert. See Figure 6.33.

	SRN-W	SRN-E	SRN-EC	SRS-W	SRS-C	SRS-SE	0
1950		20	266				286
51							0
52							0
53	151						151
54							0
55	117	97					214
56	99						99
57	641	29					670
58		20					20
59	199	23					222
1960	81	21		97			199
61	22			56			78
62		499		188			687
63	3	211		220			434
64		319					319
65		51	38				89
66							0
67							0
68	7	63					70
69	69						69
1970		99					99
71	109	75		24	43	10	261
72	130				60	64	254
73	26	166			105		297
74	179	141		47	198		565
75		161		229		46	436
76	299	222		84	379	377	1361
77	522	58	68	60	917	158	1783
78	916	176	28	103	28	14	1265
79	534			22	98	19	673
1980	657				322	88	1067
81	734	56			176	27	993
82	436	8	46		175	60	725
83	668	124	6	11	211		1020
84	431	649	302		1119	191	2692
85	360	221	381		581	26	1569
86	811	226	4		176	173	1390
87	565	1558	33		630		2786
88	658	695	514		73		1940
89	255	1083			400		1738
1990	110	884	283		5		1282
91	1364	1376	777				3517
92	996	89	322		53	127	1587
93	141	7	115		134		397
94	160			65			225
12740	12450	9427	3183	1206	5883	1380	33529

APPENDIX 13

WATERSHED DESCRIPTIONS FOR EACH BIODIVERSITY AREA WITHIN MAJOR DRAINAGES ON THE MEDICINE BOW NATIONAL FOREST

For locations of the areas discussed below, refer to Figure 6.1 (Biodiversity Areas and Biodiversity Units) in Chapter 6, and Appendix 2 (Location of Watersheds, Biological Diversity Areas and Units).

National Forest watersheds within the Little Snake River drainage

There are two Biodiversity Areas (BDA's) comprised of 19 sixth-level watersheds in this drainage. Streams within these watersheds originate at the Continental Divide and flow in a westerly to southwesterly direction from the Forest. High elevation areas are typically composed of coniferous vegetation. Low elevations have grasslands, aspen shrubland and forest, and patches of subalpine fir.

SIERRA MADRE - NORTHWEST BIODIVERSITY AREA

Major subbasins in this Biodiversity Area include Big Sandstone Creek and headwater portions of Dirtyman Creek, and the East and North Forks of Savery Creek. These streams flow into the Colorado River drainage west of the Continental Divide. Tributaries to the North Platte River include Jack Creek, North and South Spring Creeks, Teddy Creek, and Cow Creek. Comprehensive inventories or studies have been conducted by Wesche (1991) and Oberholtzer (1986, 1987). Medicine Bow National Forest fisheries personnel have also conducted stream habitat surveys on portions of Big Sandstone Creek and Savery Creek. A synopsis of these data by subbasin is included below.

Subbasins: Big Sandstone and North and East Forks of Savery Creek

Characteristics

- -Elevations range from 10,500 ft msl to 7,000 ft msl.
- -At high elevations, channels are confined by rough channel boundaries and have moderate (1.5% to 3.5%) gradients.
- -At lower elevations, channels flow through a moderately narrow canyon with less stream gradient.

Riparian vegetation

- -High elevation - spruce fir, aspen, and willow.
- -Mid and low elevation - willow, rushes, and sedges.

Landforms/Soils

-Well drained soils on steep slopes in headwaters.

-Poorly drained, deep soils on moderate slopes.

-Moderate erosion potential, except for areas immediately adjacent to the channel at lower elevations.

Water quality

-Lower reaches are vulnerable to sedimentation.

-Water temperatures range from 40 to 60 degrees F during summer months.

-No known point source pollution problems.

Watershed problems

-No widespread problems are known to occur.

Subbasins: Jack Creek, North and South Spring Creeks, and Teddy Creek

Characteristics

-Elevations range from 10,600 ft msl to 6,700 ft msl.

-High elevations have steep channels with substrates composed of small boulders and rubble.

-Mid and low elevations have moderate to low gradient channels with small boulder and gravel substrates and extensive beaver ponds.

-Low gradient channels in low elevations with gravel and sand substrate; beaver activity present.

-Narrow canyons near headwaters, and broad canyons in foothills.

Riparian vegetation

-High elevation - spruce-fir.

-Mid elevations - lodgepole, spruce-fir, and alder.

-Low elevations - dense willow stands with pockets of aspen.

Landforms/Soils

-Well drained, moderately deep soils on steep slopes in headwaters.

-Gently sloping, well drained, deep soils in foothills.

-High erosion potential near headwaters because of steep slopes.

Water quality

-Water temperatures range from 44 to 60 degrees F during summer months.

-Sedimentation problems in Nugget Creek and Placer Creek from historic mining activities.

-No known point source pollution problems.

Watershed problems

-Stream flows immediately off-Forest are diverted for irrigation purposes.

-Nugget Creek riparian areas are heavily impacted by historic mining activities.

SIERRA MADRE - SOUTHWEST BIODIVERSITY AREA

Surface Water Characteristics

Major streams include the North Fork Little Snake River, West Branch Little Snake River, Roaring Fork Little Snake River, Battle Creek, and Little Sandstone Creek. Small cirque lakes and/or

kettlehole ponds can be found at the head of North Fork Little Snake, Roaring Fork, and Battle Creek. Two of the streams in this BDU, North Fork Little Snake and Battle Creek, have been studied extensively (See Appendix 1 - Bibliography of Scientific Studies). Stream surveys have been conducted on several small tributary streams in the subbasin.

Subbasins:North Fork/West Branch/Roaring Fork Little Snake River

Characteristics

-High elevation stream channels have an average gradient from 5 - 10 percent.

-B type channels composed of cobble and/or rubble substrates.

-Lower elevation, foothills streams have lower gradients.

-Lower gradient, C type channels are present in the headwaters but comprise short distances of stream.

Riparian vegetation

-Predominately spruce and subalpine fir in B type channels.

-Lower gradient channels have rushes, sedges, willow, aspen, and cottonwoods.

Landforms/Soils

-Steep, well drained, moderately deep soils.

-Foothill areas composed of gently sloping, well drained, deep soils.

-Headwater regions have moderate erosion potential; foothills have moderate/high erosion potential.

-Valley bottom and adjacent slopes along the lower 11 miles of Battle Creek have a high erosion potential.

Water quality

-Generally good, with low stream temperatures and high dissolved oxygen levels.

-Summer temperatures range from 37 to 60 degrees F.

Watershed problems

-Some streams in the North Fork Little Snake drainage have elevated levels of copper and mercury.

-Point source pollution in Haggerty Creek from the Ferrious-Haggerty mine effluent. Copper concentrations have eliminated macroinvertebrates in approximately 4 to 5 miles of stream.

-Several streams in the headwaters of the North Fork Little Snake have been affected by sediment spill from Stage II of the Cheyenne Water Project since 1982. (See Colorado River cutthroat trout species information in Chapter 8 for details).

National Forest Watersheds in the North Platte River Drainage

There are fifteen Biodiversity Areas comprised of 120 sixth-level watersheds in the North Platte River Drainage. Streams in these watersheds originate in the Sierra Madre Mountains, the Laramie Range, and the Snowy Range. The following is a detailed description of watersheds within Biodiversity Areas on the Medicine Bow National Forest.

SIERRA MADRE - ENCAMPMENT RIVER BIODIVERSITY AREA

Location and Surface Water Characteristics

Major subbasins in the Sierra Madre-Encampment River area are the Encampment River, East Fork of the Encampment River, Coon Creek, Miner Creek, Beaver Creek, and Soldier Creek. The Encampment River is the largest stream in the region in terms of size and length. It originates in Colorado and flows north approximately 24.5 miles to its confluence with the North Platte River. Comprehensive studies or inventories have been conducted by Kanaly (1977) and Oberholtzer (no date). Stream habitat surveys have been conducted by the Medicine Bow National Forest for portions of the Encampment River, East Fork of the Encampment River, Damfino Creek, and Coon Creek. A synopsis of these data and reports by subbasin is presented below.

Sierra Madre - Encampent River Biodiversity Area

Subbasin: Encampment River mainstem

Characteristics

-Elevations range from 8,400 ft msl near the Wyoming/Colorado border to 7,000 ft msl at the confluence with the North Platte River.

-At high elevations, the channel is moderate to low gradient, flowing through open meadows; substrate is composed of small boulders and gravel.

-At mid elevations, the channel is confined through a narrow canyon; channel gradient is higher; substrate composed of large boulders and rubble.

-At low elevation areas near the Forest boundary, the valley bottom widens; substrate becomes less coarse.

-Large trees in the channel are limited due to historic tie drives.

Riparian vegetation

-High elevation - spruce-fir, willow, sedges, and rushes.

-Mid elevation - spruce-fir, lodgepole, willows, and alder.

-Low elevations - willow, aspen, rushes, and sedges.

Landforms/Soils

-Vast majority of the watershed is composed of steep, well drained, deep soils. Canyon sections have steep slopes and high erosion potential.

Water quality

-Good overall.

Watershed problems

-Historic tie drives have altered channels and riparian vegetation.

Subbasins: East Fork of the Encampment River

Characteristics

-Elevations range from 9,600 ft msl in the headwaters to 8,320 ft msl at the confluence with the Encampment River.

-At high elevations, streams are high-gradient; substrate composed of medium sized boulders with rubble and gravel.

-At lower elevations, the valley bottom is wider; the channel is more sinuous; substrates composed of small boulders, rubble, and gravel.

Riparian vegetation

-High elevations - spruce-fir and lodgepole pine.

-Mid and low elevation - scattered spruce-fir and lodgepole pine, willows, and alder.

Landforms/Soils

-Moderately dissected, deeply incised mountain slopes.

-Moderate soil erosion potential.

Water quality

-Stream temperatures range from low 40s to low 60s (degrees F) during the summer months.

-No known point source pollution problems.

Watershed problems

-Most of the larger streams in this subbasin have been tie driven.

-Lower reaches of Damfino Creek and East Fork of the Encampment River have unstable channels.

Subbasin: Hog Park

Characteristics

-Elevations range from 9,100 ft msl in the headwaters to 8,200 ft msl at the confluence with the Encampment River.

-At high elevations, channels are steep; substrate is composed of boulder and rubble.

-At mid elevations (below Hog Park reservoir), stream channels are more sinuous; substrate is comp[illegible] large boulders, small rubble, gravel, and sand.

-At low elevations, channel is moderate to high gradient; substrate is composed of boulders. rubb[illegible]

Riparian vegetation

-High elevation - spruce-fir and alder.

-Mid elevations - willow, scattered lodgepole, sedge, and rushes.

-Low elevation - spruce-fir and alder.

Landform/Soils

-Mountain slopes with moderately dissected valleys.

-Most of the subbasin has low to moderate soil erosion potential. Below Hog Park Reservoir, areas adjacent to the channels have high soil erosion potential.

Water quality

-Lower reaches are prone to sedimentation due to erosive soils and unstable channel conditions.

-No known point pollution problems.

Watershed problems

-Reaches of Hog Park Creek below the dam have been altered by sediment spills and large water releases from the reservoir. The channel is recovering but is still an area of concern.

SIERRA MADRE - SOUTHEAST BIODIVERSITY AREA

Location and Surface Water Characteristics

Major subbasins within the Sierra Madre Southeast Biodiversity area are Beaver Creek; Big Creek; and North, South, and Middle Big Creeks. Big Creek proper is formed by the confluence of its north, south, and middle forks just north of the Colorado/Wyoming border. At this point, Big Creek flows northeast approximately 14.5 miles to its confluence with the North Platte River. Major studies or inventories were conducted by Oberholtzer (1983, 1990). Stream habitat survey data on the three forks of Big Creek has been collected by the Medicine Bow National Forest. A synopsis of these data and inventories is included below.

Subbasin: Big Creek

Characteristics

-Elevations range from 11,422 ft msl near Davis Peak in Colorado to 7,320 ft msl at the confluence with the North Platte.

South Fork of Big Creek

-At high elevations, the stream is steep; substrate is composed of large boulders and rubble.

-At mid and low elevations, the stream has a moderate to low gradient; substrate is composed of small boulders and rubble.

Middle Fork of Big Creek

-At high elevations, the stream is high-gradient; substrate is composed of boulders, rubble, and gravel.

-Large wood is important in the formation of pool habitat.

-Low elevations have open meadows and a sinuous channel.

North Fork of Big Creek

-At high elevations, the stream flows through alternating canyons and open sagebrush/willow parks.

-Substrate in upper reaches is composed of large boulders and rubble with cascades common; large trees are common in the channel.

-At low elevations, the channel is more sinuous with overhanging banks and deep pools; substrate is composed of rubble and gravel.

-Beaver ponds are common in the area.

Riparian vegetation

-High elevation - spruce-fir, lodgepole, and alder.

-Mid and low elevations -sagebrush/willow, sedge, and rushes.

Landform/Soils

-Steep, well drained slopes with moderately deep soils.

-Moderate soil erosion potential in most of the area; portions of the eastern side near the Forest boundary have a high erosion potential.

Water quality

-Summer water temperatures range from 40 to 58 degrees F.

-No known non point or point source pollution problems.

Subbasin: Beaver Creek

Characteristics

-Elevations range from 10,900 ft msl near Blackhall Mountain to 7,060 ft msl at the confluence with the North Platte River.

-Headwater streams are high-gradient; substrates are composed of large boulders and rubble; large trees are abundant in the channel.

-In lower part of the drainage, Beaver Creek is low-gradient and considerably more sinuous.

Riparian vegetation

-High elevation - spruce-fir and lodgepole.

-Mid and low elevation - willows, sedges, and rushes.

Landforms/Soils

-Mountain slopes are moderately dissected and shallowly incised.

-Moderate soil erosion potential.

Water quality

-Good water quality; no known point source pollution problems.

Watershed problems

- None known.

SNOWY RANGE NORTH - NORTHWEST BIODIVERSITY AREA

Location and Surface Water Characteristics

Major streams in the Biodiversity Area include South, North, and Middle French Creeks; North and South Brush Creek; Mill Creek; North and Middle Cedar Creek; and Pass Creek. The headwater portions of the French Creeks, Mill Creek, and North Brush Creek contain high mountain lakes and/or small kettle ponds. Numerous studies and inventories have been conducted in this BDA. Major studies were conducted by Oberholtzer (1980, 1981), Kanaly and Oberholtzer (1979), and Snigg (1989). Habitat surveys have been conducted on streams in the South French Creek, North Brush Creek, and South Brush Creek subbasins.

There are over 100 lakes, small reservoirs, and ponds in the Snowy Range area of the Medicine Bow National Forest. These lakes

are located in the headwater regions of French Creek, Brush Creek, the Medicine Bow River, and the Big Laramie River. All of the lakes in the Snowy Range are considered to be typical for high-elevation environments. A complete description of the physical, biological, and chemical makeup of these lakes is provided in the major aquatic ecosystem and aquatic community composition sections of this report.

Subbasin: South French Creek

Characteristics

-Elevations range from 12,013 ft msl at Medicine Bow Peak to 7,500 ft msl at the confluence with French Creek.

-The stream originates in Lookout and Mirror Lakes and drops rapidly through a narrow canyon composed of large boulders.

-Mid elevation areas of the channel are moderate to high gradient; substrate is composed of boulders and rubble; large wood, while infrequent, creates large debris jams in various locations.

-At low elevations, the stream channel is moderately narrow with less gradient.

Riparian vegetation

-High elevation - spruce-fir.

-Mid and low elevation - willows, alder, and meadow grass with patches of conifers.

Landforms/Soils

-High elevations have alpine landforms; mid and lower elevation landform is mountain slope/canyon.

Water quality

-Good; no known point source pollution problems.

Watershed problems

-Streams in the basin have been tie driven.

Subbasin: North French Creek

Characteristics

-Elevations range from 10,200 ft msl in the headwaters to 8,000 ft msl at the confluence with South French Creek.

-Headwater streams flow through open alpine meadows; substrates are composed of rubble and gravel.

-At mid and low elevations, the channel high-gradient; substrate is composed of boulder and rubble substrates.

Riparian vegetation

-High elevation - scattered willow and spruce-fir.

-Mid and low elevations - conifers with dense stands of willow.

Landforms/Soils

-Rolling hills in the upper drainage; canyon in the lower drainage.

-Moderate erosion potential.

Water quality

-Good; no known point or non point source pollution problems.

Watershed problems

-None known.

Subbasin: Brush Creek

Characteristics

-Elevations range from 10,800 ft msl to 7,800 ft msl.

-Stream gradient ranges from low to high; substrates are composed of boulder, rubble, and gravel.

Riparian vegetation

-Willows and alders with scattered conifers.

Landforms/Soils

-Mountain slopes are moderately dissected, shallowly incised.

-Moderate erosion potential.

Water quality

-Sediment is of concern in lower portions of the subbasins.

Watershed problems

-Unstable channels and considerable sediment deposition in the lower portions of South Brush Creek and the mainstem of North Brush Creek.

-Streams in both subbasins have been altered by historic tie drives and mining activity.

Sub-basin: Cedar Creek

Characteristics

-Elevations range from 10,200 ft msl to 7,280 ft msl.

-Streams in the upper basin are high gradient; substrates are composed of gravel and rubble.

-At mid and low elevation, streams have lower gradient; substrates are composed of gravel, rubble, and small boulders.

Riparian vegetation

-High elevation - spruce-fir with alder.

-Mid elevations - scattered conifers with willow.

-Low elevations - scatter conifers and willow.

Landforms/Soils

-Dissected slopes mantled with Quaternary deposits over most of the subbasin (primarily within biodiversity areas 28 and 31). Quaternary deposits consist of alluvium, colluvium, glacial till, and other unconsolidated material and are highly susceptible to mass wasting events.

Water quality

-Sedimentation in lower portions of the subbasin.

Watershed problems

-Middle Cedar Creek has widespread channel instability, including both down cutting and scouring. The stream is channelizing and cutting off meanders.

Subbasin: Pass Creek

Characteristics

-Elevations range from 10,000 ft msl at Kennaday peak to approximately 7,000 ft msl at the confluence with the North Platte River.

-Substrate materials are affected by siltation thus limiting suitable trout habitat.

Riparian vegetation

-Riparian vegetation is composed of alder, cottonwoods, willows, and conifers.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Non point source pollution problems associated with silt and organic enrichment.

Watershed problems

-East Fork Little Pass Creek and East Fork Pass Creek have moderate gradient, deeply incised channels, and extensive deposition in the low gradient reaches.

SNOWY RANGE NORTH - NORTHEAST BIODIVERSITY AREA

Location and Surface Water Characteristics

Major streams on the Forest include the Medicine Bow River, Rock Creek, and Turpin Creek. Turpin Creek and the Medicine Bow River flow through similar landforms. At lower elevations, landforms are shallowly incised mountain slopes. Mid-elevation landforms are rounded alpine, and the headwaters landforms, near Medicine Bow Peak, are rugged alpine. Rock Creek flows through deeply incised mountain slopes in the headwaters and a canyon at mid and lower elevations.

The easternmost part of the Biodiversity Area has numerous small streams that flow through deeply and shallowly incised slopes. A thorough discussion of all three of these watersheds is found in Miller (1985). Additional data describing stream conditions are available from the fisheries staff on the Medicine Bow National Forest.

Subbasin: Medicine Bow River

Characteristics

-Elevations range from 10,980 ft msl near the base of Medicine Bow Peak to approximately 6,500 ft msl at the confluence with the North Platte River.

-Total length is 122 miles, with only 13 miles located on the Medicine Bow National Forest.

-The upper two miles flow through a series of high mountain lakes and meadows.

Riparian vegetation

-High elevation - sparse willow, grasses, and sedges.

-Lower elevation - cottonwoods, willows, and shrubs.

Landforms/Soils

-Rounded alpine hills and moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Good; no known point or non-point source pollution problems.

Watershed problems

-Low-gradient sections of East Fork Medicine Bow River have widespread evidence of channel instability.

-Wagonhound Creek has been severely affected by a washout which occurred when water was diverted from Carlson Creek into the Wagonhound Creek watershed. Lower sections of the basin show evidence of extensive impacts from livestock grazing.

Subbasin: Rock Creek

Characteristics

-Elevations range from 9,900 ft msl to 7,000 ft msl at the confluence with the Medicine Bow River.

-Rock Creek and associated tributaries have been affected by historical tie drives.

-Lower sections (beyond the Forest boundary) are affected by numerous irrigation diversions and haying in areas adjacent to the stream.

Riparian vegetation

-Riparian vegetation consists of cottonwoods and willows near the mouth of the canyon.

-The remainder of the stream has willows, alder, and conifers.

Landforms/Soils

-Infrequently dissected, deeply incised mountain slopes and shallowly incised mountain slopes.

-High erosion potential.

Water quality

-Good to fair; no known point source pollution problems.

Watershed problems

-Deep Creek below Sand Lake has been severely altered by irrigation releases from the dam.

Subbasin: Turpin Creek

Characteristics

-Elevations range from 10,100 ft msl at Cascade Lake to 8,300 ft msl at the confluence with the Medicine Bow River.

-Total length is approximately 10 miles.

-The stream flows through moderately to heavily timbered slopes interspersed with small open meadows.

-Substrate consists of mud and small gravel at lower elevations; in higher gradient areas, substrate consists of boulders, rubble, and gravel.

-Turpin Creek and some tributaries have been affected by historic tie drives.

Riparian vegetation

-High-gradient reaches - conifers and alders.

-Low-gradient reaches - willow and meadow grasses.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate to high erosion potential.

Water quality

-Good; no known point or non point source pollution problems.

Watershed problems

-None known.

SNOWY RANGE NORTH - NORTHEAST CENTRAL BIODIVERSITY AREA

Location and Surface Water Characteristics

Major subbasins within this Biodiversity Area include the North Fork of the Little Laramie River, Middle Fork of the Little Laramie River, and South Fork of the Little Laramie River. A thorough examination of the surface waters in this drainage is provided by Oberholtzer (1992), Snigg (1988), and Blake (1945). Numerous other studies have been conducted on both lakes, streams and ponds in the BDA (See Appendix 1). Stream habitat information is also available from the fisheries staff on the Medicine Bow National Forest.

Subbasin: North Fork of the Little Laramie

Characteristics

-Subbasin is located on the south and east slopes of the Snowy Range and covers a 48-square-mile area.

-Upper portion consists of alpine peaks and open meadows; mid-elevations consist of steep, timbered slopes; lower portions consist of foothills and open flats around the town of Centennial.

-Streams are moderate to high gradient; substrate is composed of boulders and rubble interspersed with gravel.

Riparian vegetation

-Riparian vegetation is composed of willows, aspen, cottonwood trees, and conifers.

Landforms/Soils

-Moderately dissected, deeply incised mountain slopes.

-Moderate to high erosion potential.

Water quality

-Good; no known point or non point pollution problems.

Watershed problems

-None known.

Subbasin: Middle Fork of the Little Laramie

Characteristics

-Subbasin is located south and east of the Snowy Range area and covers a 40-square-mile area.

-Elevations range from 10,000 ft msl in the headwaters near Fourlog Park to 7,785 ft msl at the confluence of the Middle and South Forks.

-Higher elevations consist of open meadows; mid-elevations consist of heavily timbered slopes; the foothills consist of willow and aspen near the Forest boundary and open grasslands in the Centennial Valley.

Riparian vegetation

-High elevation - forbs, meadow grasses, and sedges intermixed with willow.

-Low elevation - cottonwoods and willows.

Landforms/Soils

-Canyons and moderately dissected, deeply incised mountain slopes.

-Moderate to high erosion potential.

Water quality

-Good; no known point or non point source problems.

Watershed problems

-None known.

Subbasin: South Fork of the Little Laramie

Characteristics

-Originates on the southeast slopes of Spruce Mountain at 9,680 ft msl and flows nine miles to the confluence with the Middle Fork of the Little Laramie River.

-Substrate consists mainly of rubble, with some boulders and gravel intermixed.

-Boulders and large woody debris create pools in the stream; overhanging vegetation provides cover for trout.

Riparian vegetation

-High elevation - conifers and small willows.

-Lower elevation - Aspen, alders, and willows.

Landforms/Soils

-Moderately to infrequently dissected, shallowly incised mountain slopes.

-Moderate to high erosion potential.

Water quality

-Good; no known point or non point source pollution problems.

Watershed problems

-None known.

SNOWY RANGE SOUTH - SOUTHEAST BIODIVERSITY AREA

Location and Surface Water Characteristics

Streams in this Biodiversity Area are located in the headwater regions of the Laramie River. Major sub-drainages include Fox Creek, Bear Creek, and Boswell Creek. A thorough description of the streams within this area is found in Oberholtzer et. al. (1993) and Eaglin (1991). Additional studies have also been conducted on the aquatic resources in this BDA (Appendix 1).

Subbasin: Fox Creek

Characteristics

-Located north of Highway 230 near Foxpark. Fox Creek flows northeast 10 miles to its confluence with the Laramie River.

-Upper segment of the basin flows through alpine meadows; lower segment is on private land and nearly dry during late summer due to irrigation diversions.

-Poor habitat and riparian conditions.

-Numerous beaver dams exist on the stream.

Riparian vegetation

-High elevation - willows.

-Mid elevation - willows, alders, aspen, and cottonwoods.

Landforms/Soils

-Moderately dissected. shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Summer temperatures approximately 50-65 degrees F; no other available data.

Watershed problems

-None known.

Subbasin: Bear Creek

Characteristics

-Located in the central portion of the Biodiversity Area. Bear Creek flows east six miles to its confluence with the Laramie River.

-Substrate is composed of granitic gravel, sand, and silt.

Riparian vegetation

-Riparian vegetation consists of willows, conifers, and aspen.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Summer temperatures approximately 50-65 degrees F; no other available data.

Watershed problems

-None known.

Subbasin: Boswell Creek

Characteristics

-Located in the southern portion of the Biodiversity Area; Boswell Creek originates near the town of Mountain Home and flows approximately 8 miles to its confluence with the Laramie River.

-The stream is low gradient; substrate composed of silt-covered sand and gravel in upper reaches.

Riparian vegetation

-Riparian vegetation consist of willows with some conifers.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Good; no known point or non point source pollution problems.

Watershed problems

-None known.

SNOWY RANGE SOUTH - SOUTH CENTRAL BIODIVERSITY AREA

Location and Surface Water Characteristics

This Biodiversity Area includes the Douglas Creek drainage. The drainage is approximately 150 square miles and contains approximately 140 miles of perennial streams. The major subbasins within the drainage are upper Douglas Creek, lower Douglas Creek, Muddy Creek, Pelton Creek, Lake Creek, and Devils Gate Creek. Streams in the Douglas Creek drainage have been studied more than any other streams on the Forest. The most complete studies have been done by Wesche (1987), Jesperson (1980), Oberholtzer (1989, no date), and the Medicine Bow National Forest (1994a; 1994b). Numerous other studies, primarily by the University of Wyoming, have been conducted on this watershed (see Appendix 1). Stream habitat data for all the major streams are available from the Medicine Bow National Forest.

Subbasin: Upper Douglas Creek

Characteristics

-Originates five miles northeast of Rob Roy Reservoir, in Hat Park, at an elevation of 10,400 ft msl.

-Immediately above the reservoir dam, the stream channel has fair habitat conditions.

-Below the dam, the channel is in poor condition with side channels, little instream structure, and significant deposits of gravel.

Riparian vegetation

-Dominated by spruce-fir, lodgepole pine, willows, sedges, and aspen.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Good; no known point or non point source pollution problems.

Watershed problems

-Extensive channel instability is apparent in Elk, Dave, and Bear Creeks. In some cases, instability results from washed-out historic roads (e.g. Elk Creek).

Subbasin: Lower Douglas Creek

Characteristics

-Below Rob Roy Reservoir, the stream flows approximately 22 miles to its confluence with the North Platte River.

-Substrate composed of rubble, gravel, sand, and mud; low gradient reaches consist of beaver dams with rubble, gravel, sand, and mud substrates.

-Channel is affected by tie drives, mining, and water development.

Riparian vegetation

-Riparian vegetation dominated by willows, sedges, and rushes.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Good; no known point or non point source pollution problems.

Watershed problems

-Segments of streams have been heavily altered by historic mining and tie drives.

-Bear Creek is affected by point source pollution from the Rambler Mine.

Subbasins: Muddy Creek and Lake Creek

Characteristics

-Originate near Muddy Mountain at an elevation of 8,300 ft msl.

-Substrates are composed of small rubble, gravel, and sand.

-Beaver in lower portions of the drainages.

-Evidence of historic tie drives and mining activity.

Riparian vegetation

-Higher elevations - open parks with willows, sedges, and rushes.

-Lower elevations - willow.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Suspended sediment/siltation problems.

Watershed problems

-Channels and riparian vegetation have been altered by historic tie drives.

-Evidence of off-road recreational vehicle use along streams.

Subbasins: Pelton Creek

Characteristics

-Elevations range from 9,000 ft msl in the headwaters to 8,200 ft msl at the confluence with Douglas Creek.

-Substrate is composed of small rubble, gravel, and sand.

-Beaver activity is evident in lower portions of the watershed.

-Stream is impacted by historic tie drives and mining activity.

Riparian vegetation

-High elevation - willows, sedges, and various grasses.

-Lower elevations - primarily willows.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-High to moderate erosion potential.

Water quality

-No data available.

Watershed problems

-Channels and riparian areas have been altered by historic tie drives.

Subbasin: Devils Gate

Characteristics

-Elevations range from 9,400 ft msl in the headwaters to 7,500 ft msl at the confluence with Douglas Creek.

-Good channel conditions with numerous beaver dams in upper portions of the drainage.

-At mid and lower elevations, the channel has been impacted by historic tie drives.

Riparian vegetation

-High elevation - willows interspersed with spruce fir and lodgepole.

-Mid-elevation - willows and sedges.

Landforms/Soils

-Canyons and moderately dissected, shallowly incised mountain slopes.

-High erosion potential.

Water quality

-No data available.

Watershed problems

-Channels and riparian areas have been altered by historic tie drives.

SNOWY RANGE SOUTH - WILDERNESS BIODIVERSITY AREA

Location and Surface Water Characteristics

Major subbasins or portions of larger basins in this BDA include a 12-mile segment of the North Platte River and Mullison, Savage Run, and Cottonwood Creeks. Major studies or surveys conducted on streams in the area include Wick (1993) and basin-wide stream habitat surveys conducted on streams in the Mullison Creek subbasin by the Medicine Bow National Forest.

Subbasin: North Platte River (12-mile segment through Northgate Canyon)

Characteristics

-Flows through the North Gate Canyon in the Platte River Wilderness Area.

-Several small tributaries flow directly into the river from the east and west.

-Generally moderate to high gradient, with rapids present in many areas.

-In the upper sections of the canyon, the river is confined; velocities are high; and the substrate is dominated by large boulders.

-Lower in the canyon, the river is less confined; substrate is composed of slightly smaller boulders and rubble.

Riparian vegetation

-Willow, alder, and cottonwoods.

Landform/Soils

-Steep canyon.

Water quality

-Good.

Watershed problems

-Channel impacted by historic tie drives, but habitat conditions are good to excellent.

Subbasins: Mullison, Savage Run, and Cottonwood Creek

Characteristics

-Elevations range from 9,600 ft msl in the headwaters on the west side of the Snowy Range Mountains to 7,300 ft msl at the confluences with the North Platte River.

-Streams are moderate to high gradient; substrates are composed primarily of boulder and rubble substrates.

-Boulders and large trees create instream habitat throughout the drainages.

Riparian vegetation

-High elevation - spruce-fir intermixed with lodgepole pine.

-Mid-elevations - willows.

-Lower elevations - cottonwoods and alder.

Landforms/Soils

-Moderately dissected, shallowly incised slopes with broad upland surfaces.

-Moderate erosion potential.

Water quality

-No data available.

Watershed problems

-Lower sections of Cottonwood Creek have been impacted by livestock grazing.

-Lower sections of Savage Run Creek have been tie driven.

LARAMIE MOUNTAINS NORTH - NORTHWEST BIOIDIVERSITY AREA

Location and Surface Water Characteristics

Subbasins in this Biodiversity Area include LaPrele Creek, Box Elder Creek, and Deer Creek (tributaries to the North Platte River) and the headwaters of the North and South Fork Little Medicine Bow River. Studies conducted within these subbasins include the Deer Creek and LaPrele Creek drainages (McMillian, 1989, 1990) and the Little Medicine Bow River (Oberholtzer, 1985). Medicine Bow National Forest personnel have collected additional information on some of the tributaries in these subbasins.

Subbasins: Headwaters of the Little Medicine Bow River

Characteristics

-Major streams include Sheep Creek, Manse Creek, and Rock Creek.

-Elevations range from 8,500 to 9,000 ft msl in the headwaters on the south slopes of the Laramie Range to 7,070 ft msl at the confluence with the North Fork of the Little Medicine Bow River.

-Substrates are predominately boulder and rubble.

Riparian vegetation

-Dominant riparian vegetation is willows and scattered conifers.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-No data available.

Watershed problems

-None known.

Subbasin: LaPrele Creek

Characteristics

-Elevations range from 9,000 ft msl in the northwestern portion of the Laramie Range to 3,500 ft msl at the confluence with the North Platte River.

-Drainage is approximately 35 miles in length; channel width varies from 2 to 10 miles.

-Hydrograph is characterized by high spring peak flows and disproportionately low fall/winter base flows.

Riparian vegetation

-Composed primarily of cottonwoods, willow, and some aspen.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Summer temperatures range from 50 - 65 degrees F; no other data available.

Watershed problems

-None known.

Subbasin: Deer Creek

Characteristics

-Drainage is located on the northwestern end of the Laramie Range; drainage area is 213 square miles.

-Elevations range from 8,500 ft msl in the headwaters to 4,970 ft msl at the confluence with the North Platte River.

Riparian vegetation

-Riparian vegetation composed of willow and cottonwoods.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes; range is abutted on both sides by gently rolling plains.

-Moderate erosion potential.

Water quality

-No available data.

Watershed problems

-Irrigation diversions adversely affect fish habitat and stream channel stability.

-Channel is highly unstable with extensive raw and eroding banks resulting from livestock impacts.

LARAMIE MOUNTAINS NORTH - NORTH CENTRAL BIODIVERSITY AREA

Location and Surface Water Characteristics

Subbasins included in the BDA are LaBonte Creek and West Branch of LaBonte Creek. Limited studies or inventories have been

conducted on the aquatic resources in this BDA. The Medicine Bow National Forest conducted a beaver habitat assessment on drainages in the Laramie Range in 1992. The assessment described basic stream channel and riparian conditions. Descriptions below are based on this inventory, as well as interviews with Forest personnel knowledgeable about the area.

Subbasin: LaBonte Creek

Characteristics

-Elevations range from 8,000 ft msl in the headwaters to 4,900 ft msl at the confluence with the North Platte River.

-Hydrograph characterized by extreme peak and base flows; substrate composed of large boulders in canyon areas.

-Beaver activity present.

Riparian vegetation

-Riparian vegetation corridors are narrow and primarily composed of conifers with occasional nodes of willows and cottonwoods.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-No data available.

Watershed problems

-Evidence of localized channel instability throughout the drainage.

LARAMIE MOUNTAINS SOUTH - SOUTH CENTRAL BIODIVERSITY AREA

Location and Surface Water Characteristics

This Biodiversity Area includes the headwaters of Horseshoe Creek. Conder and McKnight (1990) conducted a comprehensive inventory of Horseshoe Creek. The Medicine Bow National Forest has collected stream habitat data on segments of Horseshoe Creek.

Subbasin: Horseshoe Creek

Characteristics

-Elevations range from 8,400 ft msl in the headwaters to 4,500 ft msl at the confluence with the North Platte River.

-Gradients range from low to high in the 35 miles of perennial streams.

-Substrate is composed of boulder, rubble, and gravel.

-Hydrograph characterized by extreme flows ranging from 0 to 12,000 cubic feet per second (cfs) at the USGS gaging station on Horseshoe Creek.

Riparian vegetation

-Low elevation - willows with sagebrush terraces adjacent to the channel.

Landforms/Soils

-Moderately dissected, shallowly incised mountain slopes.

-Moderate erosion potential.

Water quality

-Water temperatures in excess of 80 degrees F during the summer months.

Watershed problems

-Sections of Horseshoe Creek are severely impacted by irrigation diversions.

-Channel conditions are poor in lower reaches near the Forest boundary; conditions improve at higher elevations.

LARAMIE MOUNTAINS SOUTH - SOUTHERN AND LARAMIE MOUNTAINS SOUTH - SOUTHWEST BIODIVERSITY AREAS

Location and Surface Water Characteristics

The North Laramie River, and some smaller tributaries of the South Platte River, are intermittent drainages which originate in the southern and southwestern Laramie Mountains. Watersheds are relatively small. Numerous springs feed small streams at higher elevations. Many streams become subterranean at lower elevations near the Forest boundary.

Subbasin: North Laramie River

Characteristics

-Elevations range from 7,300 ft msl near Bell Mountain to 4,461 ft msl at the confluence with the Laramie River.

-Base flow averages 10 cfs; spring peak flow is approximately 200 cfs.

-Average annual precipitation ranges from 12.1 inches in the lower valleys to 15.0 inches in the higher elevations.

-Gradient is moderate.

Riparian vegetation

-Riparian vegetation consists primarily of cottonwoods.

Landforms/Soils

-Mountains and canyons in the middle portion of the watershed; arid rolling hills in the lower elevations.

Water quality

-Extensive siltation in pools and some riffles.

Watershed problems

-Water storage and irrigation diversion practices have altered the hydrologic regime and impacted fish communities.

National Forest Watersheds in the South Platte River drainage

There is one Biodiversity Area comprised of ten sixth-level watersheds. Streams in these watersheds originate in the Pole Mountain area east of Laramie, Wyoming.

SHERMAN MOUNTAINS BIODIVERSITY AREA

Surface Water Characteristics

Subbasins included in the Sherman Mountains BDA are Telephone Creek, Lodgepole Creek, and Crow Creek. The area is approximately 100 square miles. Major studies or inventories in the area were conducted by McDowell (1975), Snigg (1986), and Hensey (1993). For additional studies see Appendix 1 - Bibliography of Scientific Studies.

Subbasins: Telephone Creek, Lodgepole Creek, and Crow Creek

Characteristics

- -Elevations range from 8,600 ft msl in the headwaters of Crow Creek to 7,500 ft msl where Crow Creek crosses the Forest boundary.
- -Gradient is low to moderate for the 110 miles of perennial streams.
- -Substrates are composed of decomposed granite and boulders in the stream channels; substrates in beaver ponds are composed of mud/silt.
- -Wide-spread beaver dams create abundant pools in all drainages.

Riparian vegetation

- -Dominant riparian vegetation is willow, aspen, sedges, and rushes.

Landforms/Soils

- -High elevation - moderately dissected, deeply incised slopes; steep, well-drained, moderately deep soils; high erosion potential.
- -Lower elevations - rolling lowlands and plateaus; steep, well-drained, moderately deep soils; moderate erosion potential.

Water quality

- -Generally good.

Watershed problems

- -None known.

APPENDIX 14

WATERSHED HEALTH

CRITERIA AND ANALYSIS METHODS FOR DETERMINING WATERSHEDS OF CONCERN

INTRODUCTION

The information presented here describes the analytical processes used to develop Table 7.1 and Figure 7.1 (Watersheds of Concern on the Medicine Bow National Forest).

Watershed health on the Medicine Bow National Forest (MBNF) was assessed by examining chemical, physical, and biological integrity. Ecosystem health depends on the integrity of the basic soil and water resources and biological communities. Watershed processes influence the physical habitat in which aquatic and riparian biological communities live. Thus, modifications to the watershed affect biological diversity.

Land management activities may cause disturbances which influence watershed processes and biotic communities, but effects are often complex and incompletely understood. Effects may be beneficial for some parts of biological diversity and detrimental to others. For example, a large sediment spill in Green Timber Creek (a tributary to the North Fork Little Snake River) occurred in 1988. The spill was presumed to have an adverse impact on Colorado River cutthroat trout. Electrofishing estimates the following year revealed a significant increase in young-of-the-year fish numbers in the stream, while the number of large fish was significantly reduced. Young (1994) attributed this change in the fish community to the increased amounts of spawning gravels. More spawning habitat resulted in more young fish. However, the sediment spill eliminated the larger pools which provided habitat for adult trout and so reduced the number of larger fish in the stream.

Another factor affecting the integrity of biological communities is the interaction between species. Each organism is part of the environment of others, and each has a particular role in the structure and function of the community. These roles are referred to as niches, and they must be filled if the community is to remain stable. If habitat changes occur or a superior competitor is introduced, niche occupation may change.

A pertinent example of one species occupying the niche of another is the widespread replacement of Colorado River cutthroat

trout by brook trout on the Medicine Bow National Forest (See Species Abstract in Chapter 8 for details). At warmer water temperatures, brook trout appear to have a competitive advantage over Colorado River cutthroat trout. They have essentially replaced Colorado River cutthroat trout at lower elevations stream reaches on the Forest (DeStaso and Rahel, 1994). Land management activities which increase water temperatures (e.g. removal of stream-side vegetation) could, in theory, give brook trout a competitive edge at higher elevations, thus stressing existing populations.

WATERSHED CONDITION RATING

Various laws and regulations defining watershed health require the Forest Service to maintain soil productivity, hydrologic function, water quality, and aquatic life (USDA, 1995). Current watershed health and the risk of cumulative impacts were assessed by examining the following:

- The type and magnitude of land management activities.
- The capability of the watershed to accommodate management activities.
- The existing channel and water quality conditions.

Factors examined in detail were:

- The percent of the watershed affected by active landslides.
- The amount of the watershed with high surface erosion potential.
- The percent of the watershed affected by vegetation removal and soil disturbances.
- The streams or stream segements not in compliance with State Water Quality Standards.

The following sections provide a detailed description of the process used to evaluated watershed health.

EVALUATION OF CHANNEL CONDITIONS

Channel condition reflects climatic, physiographic, and management influences and is an essential indicator of watershed health. Two methods were used to assess channel conditions on the Forest. The first method involved the examination of hydrologic and fisheries data collected on various watersheds. Data included

basin-wide stream habitat information collected since 1989 on approximately 200 miles of stream (Schmal et al., 1989) The second method involved interviews with District personnel concerning their knowledge of the location and extent of channel disturbances.

Only perennial streams in major watersheds were surveyed. Key elements examined from stream surveys included the amount of streambank erosion and sediment transport and the condition of the substrate. Streams considered to be in an unstable condition were those with unstable banks comprising more than 20 percent of the total stream miles in a seventh- or eighth-level watershed.

For those watersheds where no quantitative data existed, hydrology, fisheries, and District personnel were asked about their knowledge of stream conditions. Criteria used to determine stream condition are as follows:

- Bank stability - More than 20 percent of the streambanks in unstable condition.

- Riparian condition - Riparian areas with evidence of management-induced impacts (removal of beaver, presence of exotic species).

- Aggradation - Stream channel bed material shows widespread evidence of aggradation. Channels characterized by extensive point bar development and frequent overbank flows. Lower gradient stream reaches are braided.

- Degradation - Stream channels show evidence of widespread degradation or downcutting. Stream channels may be deepened to such an extent that local ground water characteristics have been altered and riparian vegetation has changed.

LANDSLIDES AND SLOPE STABILITY

Landslide deposits on the Medicine Bow National Forest were mapped and ground verified in 1990 by Jim Case of the Wyoming Geological Survey, in cooperation with the U.S. Geological Survey. Three major areas of landslide activity, as well as a number of minor areas, were identified within the Forest boundary. The major areas are shown in Figure AP14.1. The following is a list of Biodiversity Areas and Units with significant landslide deposits:

MEDICINE BOW MOUNTAINS

Snowy Range North - Northwest Biodiversity Area
North Cedar Creek BDU
Rankin Creek BDU
Pass Creek BDU
South Cedar Creek BDU
Lower North Brush Creek BDU

These units are located primarily on dissected slopes mantled with Quaternary deposits (Marston & Clarendon, 1988). Quaternary deposits consist of alluvium, colluvium, glacial till and other unconsolidated soil, and rocks.

Snowy Range North - Northeast Biodiversity Area
Mill Creek

Snowy Range North - East Central Biodiversity Area
Fourmile Creek

These units are located on rounded hills mantled with Quaternary deposits (Marston & Clarendon, 1988).

SIERRA MADRE MOUNTAINS

Sierra Madre Northwest Biodiversity Area
Big Sandstone Creek

Sierra Madre Southwest Biodiversity Area
Little Sandstone Creek
East Sweetwater Gulch

These areas have dissected slopes with sedimentary lithology (Marston & Clarendon, 1988).

Areas with Quaternary deposits are highly susceptible to mass wasting because they are not naturally cohesive. Without cohesion, the unconsolidated material on these sites becomes unstable when the angle of the hillside exceeds a certain maximum value. This maximum angle that is stable and at rest is called the angle of repose (Nuhfer et al., 1993).

Activities which change the angle of repose or remove slope support can precipitate a landslide event. Removing slope support can occur through geomorphic processes (e.g.undercutting along stream banks) or as a result of management activities, such as road building or timber harvesting. Removal of tress can create problems by increasing the amount of water entering an unstable area. The

increased weight of the water, combined with its lubricating effect, can trigger a landslide event. Overloading a slope can occur when roads or buildings are constructed upslope from an unstable area.

The Sierra Madre Mountains contain areas with downslope-oriented bedding planes (the planes between layers of sedimentary rocks) which are also susceptible to landslides. The hazards associated with the unconsolidated material mentioned above also hold true for these areas.

Based upon the above information, areas with 30 percent or more of the surface covered by landslide deposits are at-risk for management-induced landslides which could affect aquatic systems.

DETERMINING A WEIGHTED AVERAGE K FACTOR

Soil erodablity was used to identify watersheds at risk from surface erosion. This was developed into an index applied to watersheds. The procedure was as follows:

1. For each watershed, an average K factor (soil erodability factor) was calculated by averaging the K factor, by acres, in each soil mapping unit in the watershed.

2. Watersheds with a weighted average K > .35 were determined to be susceptible to large amounts of surface erosion if subjected to activities that would alter ground cover or alter normal surface runoff patterns (T. John, Soil Scientist, Routt National Forest).

3. Weighted average K factors have been calculated for all watersheds on the forest. This information could be used in conjunction with Forplan outputs to assess the effects of harvest and road construction by alternative. A method of using Weighted Average K Factors has been developed by T.John.

Weighted average K factors are an index for comparing alternatives. The higher the number, the greater the potential for impacts from soil loss. They are not a prediction of erosion in tons per acre.

EVALUATION OF CUMULATIVE DISTURBED AREA

Adverse effects to aquatic resources are an indirect function of disturbance to vegetation and soil, as well as a direct function of channel disturbances. As a general rule, the probability of negative effects increases as the vegetation- and soil-disturbing activities increase (USDA Forest Service 1993).

Generally any watershed can accommodate some land-disturbing activities and still maintain good watershed health. Adverse impacts from land-disturbing activities depend on the number, type, and location of projects; watershed sensitivity; existing channel/habitat conditions; and existing watershed condition. There is broad range of variability with respect to watershed sensitivity to disturbance. Some watersheds are more sensitive to land management activities because of steep slopes and highly erodible soils. Other watersheds are more resilient and capable of accommodating extreme climatic events or higher levels of management activity.

Scale is an important consideration when assessing cumulative impacts in a watershed. Hawking (1992) found it was difficult to predict cumulative watershed effects in watersheds larger than 15,000 acres because the amount of natural variability in the system masked the effects of management activities. King (1989) recommends that hydrologists consider the potential impact of water yield increases in small headwater basins when scheduling timber harvesting and road building activities. He further emphasized caution when activities are planned in stream systems which are likely to be sensitive to streamflow modifications (i.e. streams that are presently unstable or streams that flow through landforms with high erosion potential).

Direct channel disturbances are the primary cause of concern for effects on aquatic resources. Disturbances result from increased duration of peak spring flows, from sediment loading due to mass wasting, and from surface erosion in the watershed.

For each of the eighth-level watersheds on the Forest, four characteristics were tabulated:

1. The acres of timber harvested since 1950.
2. The type of timber harvested since 1950.
3. The acres burned by fire (as recorded in the RIS database).
4. The total acres of roads.

These activities accounted for well over 95 percent of the known disturbances in each watersheds. Fire was minor contributor to watershed disturbance in all cases. The Rock Creek and Lincoln Park watersheds had the largest areas disturbed by fire.

These data were used to determine the number of hydrologically immature stands of trees in the watershed. Hydrologically immature stands are those in which root structure and canopy density have not reached the level of water use and influence present in mature stands. This concept is commonly applied to assessments of

watersheds and cumulative effects (Reid, 1993). It can be addressed by summing the acres changed to early seral stage conditions by fire, harvest, or disease and converting those acres to Equivalent Clearcut Acres (ECA). Equivalent Clearcut Acres is an evaluation tool developed by the USDA Forest Service. It is one of the criteria used to identify "watersheds of concern." When the amount of disturbance, compensated for recovery, exceeds 25 percent of the total acres in the watershed, it becomes a watershed of concern (Troendle, pers. comm., USDA Region 2, 1995).

Using ECA, it is possible to adjust for the age of clearcut harvested units as well as for the area affected by of partial cutting. ECA also considers the rate of hydrological recovery using the following equation developed by Troendle and King (1985):

Percent Water Yield Recovery = [1.0 - 0.0125(years after harvest)] x 100.

For example, in a 20-acre clearcut harvested ten years ago, the percent water yield recovery would be 87.5. Multiplying the percent water yield recovery by the acreage (20 acres) gives an ECA of 17.5 acres. For harvesting activities other than clearcuts, the ECA is adjusted based on the amount of basal area removed from the site. In a 20-acre partial cut, harvested ten years ago, with 30 percent of the basal area removed, the percent water yield recovery is also 87.5. To calculate ECA, the percent water yield recovery is multiplied by 20 acres. This value is then multiplied by 0.30 (30 percent of the basal area removed) to yield an ECA of 5.25 acres. In other words, a ten-year old, 20-acre partial cut is assumed to have the same impact as a 5.25-acre clearcut today. Fires were treated like clearcuts for the analysis.

Acres of roads in the watershed were determined by multplying road length by an average road width. One acre of road is considered to be one ECA since roads remain devoid of trees due to vehicle use and maintenance.

Other management activities which cause soil disturbance or the removal of vegetation were tabulated through a watershed assessment conducted by The Medicine Bow National Forest in 1994. Procedures developed by Ohlander (1993) were used to tabulate the type and extent of disturbances. Other management features considered in the calculation of ECA were pipelines, canals and ditches, utility corridors, heavy use sites (recreation), and mining areas where ground cover was removed. In most watersheds, these features accounted for less than one percent of the total acres of disturbance.

WATER QUALITY STANDARDS

Water quality data from the Medicine Bow National Forest was reviewed to determine compliance with State Water Quality Standards for point and non point source pollution (Wyoming Department of Environmental Quality, 1990).

LITERATURE CITED

DeStaso, J. and F. J. Rahel. 1994. Influence of water temperature on interactions between juvenile Colorado River cutthroat trout and brook trout in a laboratory stream. Transactions of the American Fisheries Society 123:289-297.

Hawking, C. P. 1992. Cumulative watershed effects: an extensive analysis of responses by stream biota to watershed management. End of Year Report, Cooperative Agreement PSW-88-0011CA.

King, J.G. 1989. Streamflow responses to road building and harvesting: a comparison with equivalent clearcut procedure. USDA Forest Service INT-401, Intermountain Research Station, Ogden, Utah.

Ohlander, C.A. 1993. Water Resource Analysis - Part 1 & 2. USDA Forest Service, Rocky Mountain Region.

Reid, L. M. 1993. Research and cumulative watershed effects. USDA Forest Service PSW-GTR-141, Pacific Southwest Research Station.

Schmal, R. N., S. J. Kozel and S. S. Marsh. 1989. A Basin-wide inventory approach using a habitat classification system for resident trout. USDA Forest Service. Medicine Bow National Forest. Laramie, Wyoming.

USDA, Forest Service. 1993. Determining the risk of cumulative watershed effects resulting from multiple activities. USDA Forest Service.

USDA, Forest Service. 1995. Watershed conservation practices handbook. USDA Forest Service. Rocky Mountain Region.

Wyoming Department of Environmental. 1990. Water Quality Rules and Regulations. Cheyenne, Wyoming.

Young, M. K. 1995. Conservation assessment for inland cutthroat trout. USDA Forest Service. General Technical Report, RM-GTR-256.

MEDICINE BOW NATIONAL FOREST

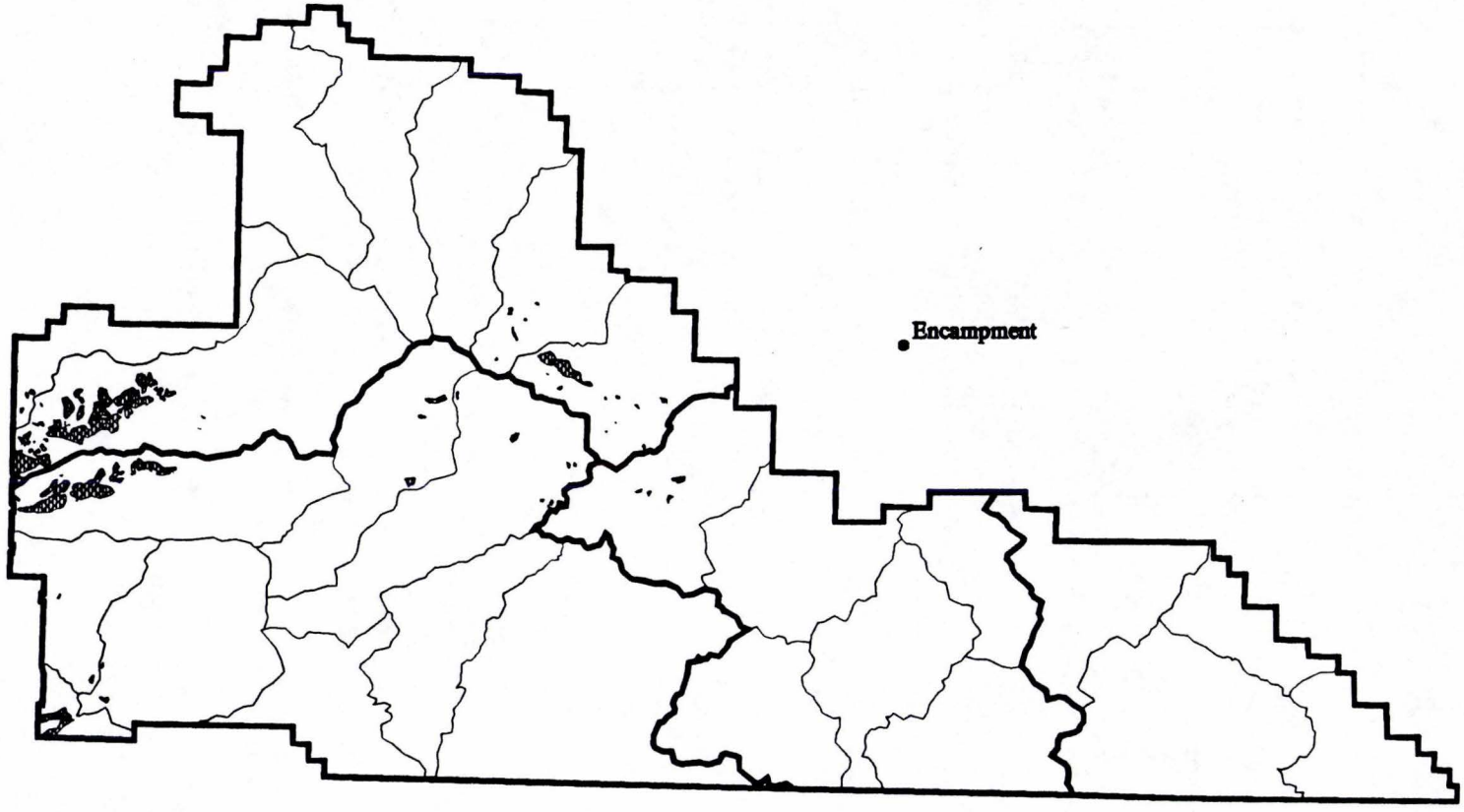
SIERRA MADRES

Wyoming Landslide Classification Areas

FIGURE AP 14.1a

LEGEND

- Wyoming Landslide Classification Polygons, by James C. Case, Geological Survey of Wyoming, 1989
- Biodiversity Unit Boundary
- Biodiversity Area Boundary



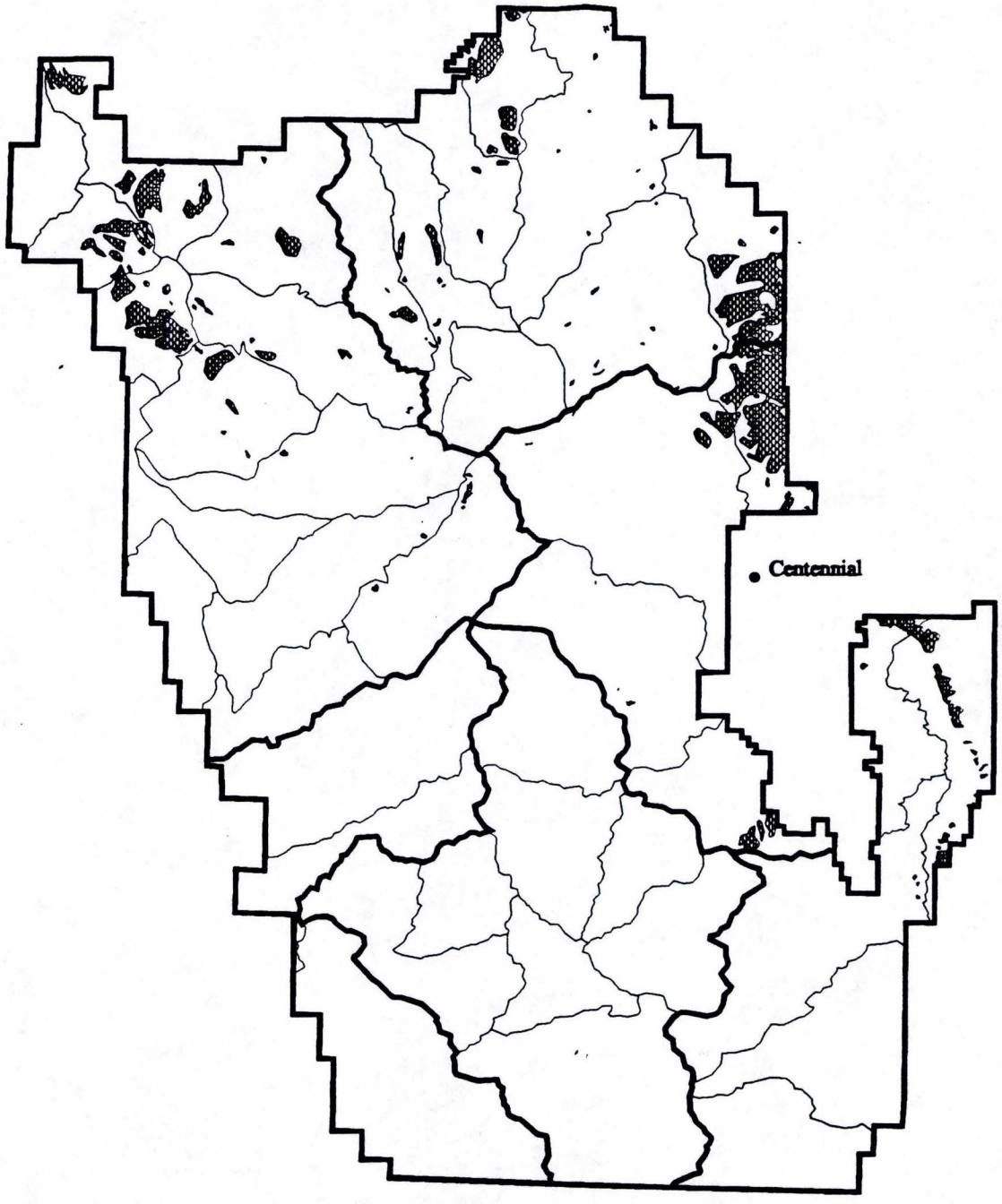
Scale 1 to 375,000

Created by CLT for JVA, 01/19/95, slides_sierra.aml

MEDICINE BOW NATIONAL FOREST — SNOWY RANGE

Wyoming Landslide Classification Areas

FIGURE AP14.1b



Created by CLT for JVA, 08.17.95, slides snowy.aml

LEGEND

- Wyoming Landslide Classification Polygons, by James C. Case, Geological Survey of Wyoming, 1989
- Biodiversity Unit Boundary
- Biodiversity Area Boundary

Scale 1 to 375,000

APPENDIX 15

FIRE OCCURRENCE ON THE MEDICINE BOW NATIONAL FOREST 1945-1993 AND FIRE HISTORY

INTRODUCTION

An analysis of post-1945 fires on the Medicine Bow National Forest is presented in this appendix. The data includes number of fires, size class, cause and acreage burned. 1945-1993 is the period of time for which consistent fire records are available in Laramie. Data is presented for the four discontiguous mountain areas of the Medicine Bow National Forest (Sierra Madre Mountains, Medicine Bow Mountains, Laramie Mountains and Sherman Mountains), and then compared to Regional and state fire occurrence data.

Information on the Sierra Madre Mountains is further stratified by the Continental Divide into east and west portions. The Medicine Bow Mountains and Laramie Mountains are divided into northern and southern portions. Differences in patterns of fire size, cause, numbers, and area become apparent when the data are analyzed within and among mountain geographic units.

ANALYSIS PROCEDURE

Official records in the Medicine Bow National Forest Fire Log Book are handwritten chronological entries which include Forest Service District, Township, Range and Section locations (TRS), date, fire name, fire cause and fire size classes (A-F). Additionally, the Fire Log documents the amount of acreage burned on and off NFS lands for larger fires. The record analyzed here includes fires from August 8, 1945 through September 6, 1993.

The information was transcribed into a Quattro-Pro database to facilitate sorting, grouping, summing and averaging. Criteria used to insure data quality and consistency were:

1. only fires with date, location, size and cause were included in the database (a few entries were incomplete)
2. if multiple sections were listed for a fire, the most northwesterly section was used as a location
3. only fires which were within Forest administrative boundaries were included
4. total fire acreages were used.

The database was sorted in various configurations to tally information on number, size class, year and cause. Coded fire locations were placed on topographic maps and tallied by watershed and approximate elevation. Elevation distribution of fires was obtained using the most northwesterly TRS location to assign an elevation category. This permitted an approximation of fire occurrence and size by 500 foot contour intervals.

The number of fires was obtained directly from the data. Fire density could be calculated using approximate acreages for each mountain range. Number of fires was standardized to fires per million acres (#/MM ac) and acres burned was standardized to acres burned per million acres (Ac burned/MM ac) for comparision to statistics from other areas as well as within the Medicine Bow.

Acres burned were recorded in the Fire Log for most fires in the larger size categories (C,D,E,F) but not always for size A (less than 0.25 acres) or B (0.26 acres to 9.9 acres). Acreage burned was estimated using the median areas of fire size class times the number of fires for fire size classes A, B and C, added to actual acreage burned for fire size classes D, E and F.

The data is presented in tables and graphs by mountain range and by subdivisions of mountain ranges. The data include number of fires, fire size class, acreage burned for man-caused and lightning-caused fires and elevation category.

There are limitations to the interpretation and use of information available in these data. The records do not indicate what kinds of cover types were burned. Thus it was not possible to separate grassland, shrubland or forest fires. The records do not indicate whether the fire was a ground fire or canopy fire. The acreage figures are approximate, as are statistics given for number of fires or acres burned/million acres.

RESULTS AND DISCUSSION

The data show a background pattern of natural lightning-caused fires which are related to geographic location and elevation. Fire occurrence patterns differ among the four discontiguous units of the Medicine Bow National Forest. The data also gives quantitative information on the occurrence of man-caused and lightning-caused fires. (Man-caused is used as a simpler term for anthropogenic).

NUMBER OF FIRES

In the 48-year period from August 8, 1945 to Sept. 6, 1993, approximately 1600 fires were recorded. 1465 fires were used in the data set. The elevation range of the fires was 5500 to 11,000 feet.

Sixty-nine percent of the fires were between 7000 and 9000 feet. Per cents are rounded to the nearest per cent above 1%. Because of rounding of numbers, sums for per cents will not always total exactly 100%.

Table AP15.1 contains information on the number of fires, and percentages of fires by cause and acreage burned in each of the four discontiguous mountain units. Table AP15.2 presents the data by cause and fire size for each unit. Table AP15.3 shows number of fires by elevation category by 500 foot contour intervals.

Figure AP15.1 summarizes the number of fires by elevation for each unit. Figure AP15.2 displays the same kind of information by the mountain ranges which are subdivided into east and west for the Sierra Madre and north and south for the Medicine Bow and Laramie Mountains. Figure AP15.3 shows the cause of fires in each mountain range. Figure AP15.4 shows the cause of fires by subdivisions of each mountain range.

There are substantial differences among the four mountain units with regard to the number of fires and the elevations at which they occurred. The Sierra Madre and Sherman Mountains had very few fires overall and most were at middle elevations (8000-9000 feet). The number of fires for both the Medicine Bow Mountains and Laramie Mountains was much greater. The difference is that in the Laramie Mountains most fires were at the lower elevations (6000-7000 feet), in contrast to most fires at 8500-9000 feet in the Medicine Bow Mountains and Sierra Madre Mountains. Note that most of the fires are at elevations in which lodgepole pine is presently the dominant cover type (8000-9500 feet) in the Medicine Bow Mountains. The lower elevations (6000-7500 feet) in the Laramie Mountains contain mainly shrubland-grassland vegetation types or ponderosa pine savanna.

A detailed analysis by area within mountain ranges is presented in Figure AP15.2. Figure AP15.2A shows most fires in the Sierra Madre Range occurred east of the Continental Divide. In the Medicine Bow Mountains (Figure AP15.2B), more fires occurred in the southern part than the northern part except at the 9000-9500 foot elevation. In the Laramie Range, the number of fires in the northern and southern part of the range was about the same above 7500 feet but there were 3 to 6 times more fires at lower elevations of Laramie Range south than Laramie Range north. The Sherman Mountains were not divided into smaller analysis units.

The graphs in Figure AP15.3 show the differences by mountain range for man-caused and lightning-caused fires. The small number of fires for both the Sierra Madre Mountains and Sherman Mountains were about equally caused by man and lightning (Figures AP15.3A and

AP15.3D). In contrast, many more fires, especially at 9000-9500 foot elevation in the Medicine Bow Mountains were man-caused. In total, there were about twice as many man-caused fires as lightning-caused fires for this mountain range (Figure AP15.3B). In the Laramie Range the number of lighting-caused fires exceeds the number of man-caused fires at most elevations by a factor of at least 6.

A comparison of fires caused by man, with fires caused by lightning for subdivisions of the ranges, shows the numbers of man and lightning-caused fires were approximately equal both east and west of the Continental Divide in the Sierra Madre (Figures AP15.4 A,B). In both the north and south areas of the Snowy Range, there were greater numbers of man caused fires at all elevations, but especially from 9000-9500 feet (Figures AP15.4 C,D). In the Sherman Mountains lightning and man-caused fires were of about equal frequency (Figure AP15.4G). Lightning-caused fires were five to eight times as frequent in the southern part of the Laramie Range as man-caused fires (Figures AP15.4 E,F).

Fire occurrence per million acres is presented in Table AP15.4. To calcuate number of fires per million acres, or acres burned per million acres, the following figures were used for the Medicine Bow National Forest. Total Acres: 1,093,342 (1985 Forest Plan); Sierra Madre Mountains, 365,000 acres; Medicine Bow Mountains, 533,000 acres; Sherman Mountains, 56,000 acres; Laramie Mountains, 441,000 acres (GIS estimates rounded to nearest 1000 acres). A gradient of fire frequency from west to east is evident.

Figure AP15.5 shows the number of fires per year due to lightning or man. Lighting fires occurrence has a loose relationship to annual precipitation means. Most of the years with a high incidence of lighting-caused fires were also below the mean for precipitation when climate records from Encampment, Foxpark, Centennial and Double-4 Ranch were compared to the fire patterns. The years 1962 and 1979 were both above-normal years for precipitation at the Double-4 Ranch, but were high-incidence lightning fire years in the Laramie Mountains. Also, although 1988 was dry (69-75% of mean annual precipitation), only the Sierra Madre had many fires (8). Two were man-caused. Dryness was not equitably distributed among all mountain ranges which accounts for some of the variability between dry years and lightning fires. The signal for dry years is weakly seen in the graphs for the Sierra Madre and Sherman Mountains (Figures AP15.5A and AP15.5B). Figures AP15.5C and AP15.5D for the the Laramie Mountains and Medicine Bow Mountains show the same general pattern.

Numbers of man-caused fires often decrease in years with a high incidence of lightning-caused fires, possibly because of fire bans. There is no clear trend of overall increase over time of man-

caused fires on a forest-wide basis (Figure AP15.5). The number of man-caused and lightning-caused fires is highly variable from year to year.

When the occurrence of lightning-caused fires is examined by mountain range, the background frequency is very low for the Sierra Madre Mountains and Sherman Hills (0 to 7). The underlying lightning-caused fire frequency is also quite low for the Medicine Bow Mountains (0-10). In stark contrast is the very high incidence as well as high variablity of lighting-caused fires in the Laramie Mountains (Figure AP15.5). When this data is put in equivalent acres basis, the incidence (but not the variablity) becomes high for the Sherman Mountains also.

FIRE SIZE AND AREA BURNED

Burn acreage figures were available for all but one Class E fires, all Class F fires and for most fires in classes C and D. Acreage data were intermittently recorded for fires in classes A and B. In order to estimate burned acreages to supplement the data on fire numbers, the median acreage for size classes A, B, C, and D was multiplied times the number of fires. The median acreages are: Class A (0.125 ac); Class B (5 ac); Class C (45 ac); Class D (200 ac).

The relationship of fire size, number and area burned is presented in Tables AP15.5 and AP15. 6 and Figure AP15.6. Fires in size classes A and B (9.9 acres or less) comprise 95% of the total fires which occurred from 1945-1993. A total of 17 fires were in size classes E (300-999 ac; 14 fires) and F (1000-4999ac; 3 fires,) during that period of time. There were no class G fires (>5000 ac). The 1465 fires tallied burned approximately 29,000 acres.

Although fires in classes A, B, C, and D comprise 99% of the fires from 1945-1993, this accounts for only 29% of the acreage burned. If only fires in classes A and B (less than ten acres) are counted) then 74% of the fires burned about 7% of the total acreage. In contrast the 17 class E and F fires (less than 1% of the total fires) account for 72% of the total acres burned.

Tables AP15.7 and AP15.8 provide detailed information for the large fires. Of the 17 Class E and F fires from 1945-1993 one fire was caused by lightning, and sixteen were caused by man. A total of 20,500 acres were burned in these 17 fires. Twenty-two percent of this acreage was burned by one lightning-caused fire in the southern Laramie Range. Six years (1952, 1955, 1962, 1964, 1979 and 1987) had high numbers of lightning-caused fires. Of the Class E and F fires, 5 of 14 class E fires and none of the Class F fires occurred

during these years. The one lightning-caused Clss E fire occurred in 1960 which was not a year of high lightning fire incidence (Figure AP15.5). A reasonable conclusion is that most of the acres burned on the Medicine Bow National Forest since 1945 have started from anthropogenic causes and are not well-related to annaul precipitation amounts.

Figure AP15.7 summarizes the relationships among elevation, number of fires, cause and acres burned for each of the four mountain units. It is evident from this data that lightning is the most important cause of fire in the Laramie Mountains (especially the southern half) and man is the most important cause in the Medicine Bow Mountains. A few man-caused fires have created large burn acreages in the Medicine Bow Mountains compared to numerous small (Class A and B) burn patches caused by lightning (Figure AP15.7B). The same kind of pattern involving Class A and D patches, involving less acreage and fewer fires is evident on the Sierra Madre Mountains (Figure AP15.7 A).

In the Laramie Mountains (Figure AP.57D), large acreages were burned from man-caused fires, but the acreage anount is more equal to lighting-caused fires than in the Medicine Bow Mountains. The Sherman Mountains have about equal numbers of man-caused and lighting caused fires, but few acres burned from either.

It is not possible to estimate how large any individual fire may have gotten without fire suppression because both man-caused and lightning-caused fires are suppressed. With the exception of the large (4450 acre) Collins Creek fire, in July, 1986 in the southern Laramie Range, all large fires which occurred were man-caused. Regardless of "natural" numbers and sizes of fires (i.e. lightning started fires) prior to 1850, there is no question that the frequency of fires has increased, especially in the Medicine Bow Mountains. There is also no question that most of the acreage burned has not been due to fires which started from lightning from 1945-1993.

COMPARISON TO REGIONAL FIRE OCCURRENCE PATTERNS

This portion of the fire history analysis presents a comparison of fire occurrence on the Medicine Bow National Forest with similar data for the Routt and Roosevelt National Forests for the period 1960-1973. Statistics for larger areas (Idaho, Montana, Wyoming and Colorado, and Forest Service Regions 1, 2 and 3 are also presented.

A comparison of the number of man-caused and lightning-caused fires from 1960-1993 in both absolute numbers and number of fires

per million acres is presented in Table AP15.9. Per million acres, the Medicine Bow NF has more lightning-caused fires than either the Roosevelt NF or the Routt NF. There are fewer man-caused fires on the Medicine Bow NF than on the Roosevelt NF, but more than on the Routt NF. Among the three forests, the Roosevelt NF had the most acres burned per million acres from all causes. The Routt NF had the fewest. The Medicine Bow NF had the most acres burned from lighting (1576 ac/MM ac) and over twice that number from man-caused fires. Table AP15.10 presents a breakdown of the same statistics for the Medicine Bow by area. It is immediately apparent that the man-caused fires in both the Medicine Bow and Laramie Mountains are responsible for the highest ac burned/MM acres. Lightning-caused fires in the Laramie Mountains are the other major factor for burned acreage.

Tables AP15.11 and AP15.12 present statistics for the number of lightning and man-caused fires by size class on three forests. These figures are not adjusted per MM acres. Class A fires comprise 2/3 to 3/4 of all fires on all three forests during that time period. The two class F fires (Roosevelt and Medicine Bow) were both man-caused. The Routt had a high proportion (73%) of lightning-caused Class B fires, but all other Class B fires were 16-29% of the total number of fires. The Medicine Bow had the most lightning-caused Class C fires. Table AP15.10 shows the distribution of the size and number of fires within the Medicine Bow National Forest. Lightning-caused fires in the Laramie Mountains were responsible for the greatest number (149) of Class A fires. Man-caused Class A fires (94) in the Medicine Bow Mountains were the next-largest group. The greatest number of Class B fires were also lightning-caused in the Laramie Mountains.

The number of lightning and man-caused fires by state are presented in Tables AP15.13 and AP15.14. Wyoming had the lowest fire occurrence per million acres as well as the fewest overall fires among the five Rocky Mountain states. A comparison of fires/MM acres for various areas of the Medicine Bow National Forest with the state averages shows the Medicine Bow had 2 1/2 times more fires per MM acres than the Wyoming state average. In contrast, the Routt National Forest had fewer fires per MM acres than the Wyomng state average and about 37% of the Colorado State average.

Comparison of acres burned for Tables AP15.9 and AP15.10 points out a similarities between the Sierra Madre Mountains and Routt National Forest, namely both have the fewest acres burned per MM acres). High fire occurrence per MM acres for is a similarity for the Sherman Mountains and the Laramie Mountains. The Sherman Mountains and Laramie Mountains have a higher acres burned/MM acres than the average for Idaho. These figures can be compared to the data for the longer time period (1945-1993) in Table AP15.5. The

above points out the variation in fire accurrence within two very different kinds of mountain areas in the Mediicne bow National Forest.

The small area for both the Sherman Mountains and the Laramie Mountains (56,000 acres and about 441,000 acres respectively, relative to Nationla Forest lands in Idaho and Montana) coupled with the large amount of non-forested area and removal of fuel by livestock, decreases the probability for actual occurrence of large, destructive fires caused by lightning, despite the statistical implications when fire occurrence is expressed as number of fires or acres burned, per million acres. The large number of acres burned per million acres due to man-caused fires in the Medicine Bow Mountains (Table AP15.5) should be a caveat to do further analysis of factors contributing to man-caused fires in the Medicine Bow Mountains since this area is a major source of wood fiber product and forested habitat on the Medicine Bow National Forest.

PRE-1945 FIRE HISTORY

The MEDICINE BOW COLLECTION at the American Heritage Center, University of Wyoming, contains reports by Forest Supervisors and Rangers, letters, memos, newspaper articles and photographs, which provide information on the fire history of the Medicine Bow National Forest from about the mid-1800s to the 1950s. Supervisors James Blackhall and William Coughlin were very interested in the logging and fire history of the Sierra Madre and Medicine Bow Ranges, and solicited information during their tenure as administrators priot to 1925. **The Report for the Forest Atlas, Cheyenne National Forest** (1909) contains valuable observations from John Mullison who came to Wyoming in 1867 at age 25 and took up ranching in the Saratoga area. In his later years he was a Ranger on the Brush Creek District and wrote many descriptions of the Medicine Bow Mountains. Reviews of National Forest activities, including fire occurrence from 1902-1952 were prepared in 1953, as part of the 50th anniversary celebration of the creation of the Medicine Bow National Forest.

Although not all fires are recorded, nor is there much information on acreages, records do indicate that fires became increasingly frequent, larger and more severe as a result of tie hacking and associated slash buildup, and ignitions caused from sawmills, mining and other human activity.

The largest and best-known fire prior to the advent of the telegraph lines and railroad building era (after 1861) was the Battle Mountain fire in 1841 which was a direct result of conflict between fur trappers and indians (Thybony et al, 1986). This large fire in the southwestern part of the Sierra Madre mountains burned

several thousand acres in the Battle Creek Valley, and is responsbile for the extensive aspen stands in the southwestern Sierra Madre. The fire may have been deliberately set by the indians to drive away the fur trappers. Trees which have regenerated in this area are a maximum of 153 years old.

Forest fires became more frequent in the early 1860s as a result of military activity and increased travel on the Oregon Trail. Travel routes along the west side of the Sierra Madre (Savery Creek drainage), through the Laramie Plains, across the northern end of the Medicine Bow Mountains (Overland Trail), up the North Platte River and across the north end of the Laramie Mountains (Oregon Trail) exposed the lower elevations to man-caused fires.

> "Although owing to the whole forest being practically in a virgin state, with no slash, and at the time having very little windfall, these fires were not so destructive to the timber nor did they sweep over such large areas as later. Cutting had been confined to isolated patches in the foothills" (Mullison and Lovejoy, 1909).

By 1865 most streams had some settlers. In 1865 construction began on the the Union Pacific Railroad. By 1868, the Union Pacific had reached the Laramie Plains and the base of the Medicine Bow Mountains.

The Laramie Mountains and Sherman Mountains were important sources of pine timber for the transcontinental telegraph line (1861) and to build Fort Laramie. By 1868, with the arrival of the railroad over Sherman Hill into the Laramie Plains, much of the major fire and logging impact, in the Sherman Mountains was over. Hillsides in the Sherman and Tie siding area were reported stripped for cordwood and ties by 1867 (Mullison and Lovejoy, 1909). In addition to these activities around lower elevations, the discovery of gold on Douglas Creek in the early 1860s brought settlement to higher elevations. The major thrust of mining activity took place between 1880 and 1900 in the Medicine Bow and Sierra Madre Mountains. Stand origin dates attest to widespread fires during this period. Old spruce forest on Libby Flats was burned about 1868.

Within three years of the award of contracts for tie-hacking (1867), fires began to occur with great frequency in the cut areas. This was attributed to the presence of large amounts of slash which provided a flammable fuel source. Stands originating since this time are about 130 years old or younger. From 1868-1870 every driveable stream on the east side of the Medicine Bow Mountains as well as French Creek and Douglas Creek had tie camps (Mullison and

Lovejoy, 1909). Portable sawmills became available in 1870 and fires increased because of these. The Baldy Mountain Fire burned a 1/2 mile by 15 mile swath along Brush Creek but the Barrett Ridge Fire was stopped by tie cutters (Mullison and Lovejoy, 1909).

Some fires were deliberately set. In 1872 a fire was set on Douglas Creek to drive cattle out in the fall. In 1878 a fire in sagebrush began during a tie drive near Jelm (Smith, 1924).

Increasing numbers of fires are noted after 1890, possibly because that was within 20 years of the 1909 report and there were people available who remembered these fires or they were recorded in old newspaper articles. Between 1892 and 1902 at least 4 large fires were mentioned for the Sierra Madre (Cow Creek, Calf Creek (1892); Spring Creek (1893). At least 6 fires occurred in the Medicine Bow Mountains in the last two decades of the 1800s (Chimney Park (1892); Fox Creek and near Centennial (1893); Devils Gate (1896); Porter Creek (1900); Sevenmile (1901). Records note that 20 townships were destroyed by great fires of 1902 (Saratoga paper, 1934).

A change in fire activity resulted from the creation of the Cheyenne National Forest in 1902 (Medicine Bow Mountains); the addition of the Sherman Mountains in 1905 (as the Pole Mountain Unit); and the Hayden Forest in 1906 (Sierra Madre Mountains). Slash cleanup was required, timber cutting was regulated and fire discovery and suppression activities resulted in a dramatic drop in both the number of fires and the acres burned.

> "Since the creation of the Forest, fires have become almost a thing of the past. Not over 50 acres have been lost since 1903 (Mullison and Lovejoy, 1909).

A fire lookout was established on Medicine Bow Peak in 1909. By 1935 there were six fire lookouts in the Medicine Bow Mountains and two in the Sierra Madre (Wood, pers. comm). Also in 1935 the Laramie Peak District (Douglas District) was added to the Medicine Bow National Forest and an additional fire lookout was placed in Black Mountain in 1954. Thus, since about 1910, very limited areas have been revenerated by fire compared to the larger areas burned between 1865 and 1910.

In the 1909 Forest Atlas there was an estimate of 275,000 acres of merchantable timber. 85,000 acres were in pole-sized restocked burns (presumably most were in productive areas). Thus it appears that about 24% (85,000/360,000 acres) of productive lands were in pole timber stages as a legacy of the fires since about 1860. Additional acres were in poorly stocked burns (Mullison and Lovejoy, 1909).

The hazard of fire was not considered great in uncut stands. A 1915 report indicated that new silvicultural practices reduced the fire hazard even more because the cut stands were thinned and the slash disposed of.

> "Areas which have been cut over under National Forest Adminstration present even less fire menace than the virgin stands" (Medicine Bow National Forest, 1915).

Between 1917 and 1920, 3672 acres of brush piles were burned on the Medicine Bow National Forest (Hilton, 1922). In the 1925 plan for the Hayden National Forest (Sierra Madre) the, fire situation was evaluated:

> "The fire hazard on the Hayden is not high, but we have large areas of timber in which it is possible for disastrous fires to occur. No special men are kept for fire patrol...the worst fire hazard we had was in the old Carbon Timber Company slashing, but these have now been broken down by sheep so this menace has been greatly reduced." ..... "We do have many tourists and the people who use the forest are pretty well familiar with conditions and are careful about handling fires in the woods. When roads make the timbered areas more accessible, it may be necessary to have additional patrol to take care of tourists". (Hayden Forest Plan, 1925)

A 1924 report for Forest Protection Week (USFS, 1924) reported:

> "It is true that we have an occasional fire started by lightning, but we have never had a bad or destructive fire except those which were caused by some person being careless".

Several reports indicated that there were never problems with restocking of stands with lodgepole pine in the Sierra Madre or Medicine Bow Mountains after a burn (Mullison and Lovejoy, 1909; USFS, 1915). A nursery was established at the Pole Mountain work center in 1922 for restocking the Sherman Mountains (USFS, date??).(I-15)

Several fires were noted in reports from 1902 through 1950, including Turpin Creek (1915); French Creek (1930); Toltec (1931). The 1952 50th Anniversary Report states that there were 978 fires which burned 8874 acres between 1909 and 1951 (42 years) (Jouch and Williamson, 1952). In contrast about 1600 fires burned an estimated 29,000 acres in the 48 year period from 1945-1993.

In summary, it seems reasonable to conclude that fire occurrence has gone through three distinct phases since fur trappers, miners, and settlers came to the area. Effects differ for the Sierra Madre, Medicine Bow Mountains, Sherman Mountains and Laramie Mountains. These impacts include:

1. a few large man-caused fires between about 1840-1870. (This includes Battle Creek, and possibly some of the fires on Libby Flats which burned spruce-fir near the trails which crossed the Snowy Range). Fires and logging severely removed timber from the Sherman Hills. Fire regimes in the Laramie Range are unknown.

2. numerous fires from about 1870 until about 1910. Most of the effects from these fires are in the Sierra Madre (except for higher elevations and rugged topographic areas), the southern Medicine Bow Mountains and areas near the edges of the Medicine Bow Mountains. Slash from tie-hacking and other cutting contributed to large, destructive fires. Ignition rates were increased by human activity, especially in the Medicine Bow Mountains.

3. few acres burned in many small fires, larger acreages burned in a few large man-caused fires from 1911-present. Ignition rates continue to increase from human activity, but increasingly effective fire suppression limits the size of all fires (1911-present).

The amount of lightning in the Laramie Mountains and Sherman Mountains is very high, but the small area, limited amount of forest and removal of much of the flammable herbaceous biomass by livestock and wildlife, coupled with effected fire suppression reduces the risk of large or frequent wildfires. In the Medicine Bow Mountains, the greatest fire risk is from man-caused fires. The background fire occurrence from lightning is low, especially for spruce-fir at high elevations. The Sierra Madre has even lower historical fire occurrence patterns and lower possiblities of fire than the other ranges. The Sierra Madre fire occurrence regime is more similar to the fire regime on the Routt NF than to the other areas on the Medicine Bow NF.

The large fire in 1841 in the Battle Creek area, which resulted in the extensive aspen stands was an unusual, man-caused event, and although such a fire is probably within the range of natural fire occurrence, the probability of such an event appears to be low given current fire management policy and fure suppression activity. The same is true for the man-caused fires at high elevations (about 10,000 feet).

"This is true, that we have an occasional fire started by lighting, but we have never had a bad or destructive fire except those which were caused by some person being careless. The big burned over areas near Gramm, on Sevenmile Creek, on Turpin Creek, on the Bow River and and North Brush Creek were caused because a camper forgot to put out his fire, the railroad patrol did not extinguish the grass fire started by a spark from an engine or because someone threw an unextinguished cigarette into some dry grass" (Medicine Bow National Forest (1924).

LITERATURE CITED

Barrows, J.S., Sandberg, D.V. and J.D. Hart. 1975. Lightning Fires in Northern Rocky Mountain Forests. Unpublished Report Department of Forest and Wood Sciences College of Forestry and Natural Resources Colorado State University, Fort Collins, CO and the Rocky Mountain Forest and Range Experiment Station (RMFRES Library - Unpublished Reports, Fort Collins, CO)

Barrows, J.S. 1978. Lightning Fires in Southwestern Forests. Unpublished Final Report Cooperative Agreement 16-658 between the Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station and the Rocky Mountain Forest and Range Experiment Station. (RMFRES Library - Fort Collins, CO)

Barrows, J.S. and K. C. Ryan. 1976. Forest Fires Hazard and Risk in Colorado. Unpublished Final Report of the Eisenhower Consortium and partial fulfillment of MS requirements for K.C. Ryan. Eisenhower Consortium Agreement 16-359-CA and 16-468-CA. (RMFRES Library- Fort Collins, CO)

Hayden Forest Plan. 1925. Medicine Bow Collection. American Heritage Center, Laramie, WY.

Hilton, H. C. 1922. Letter to the District Forester January 18, 1922. Medicine Bow Collection. American Heritage Center Laramie, WY.

Jouch, J. and C.Cilliamson. 1952. Statistics for Medicine Bow 50th Anniversary, 1902-1952. Medicine Bow Historical Infomration files, USFS Laramie IN: Medicine Bow Collection. Americian Heritage Center, Laramie, WY.

Medicine Bow National Forest. 1915. Informational letter to the District Forester. Medicine Bow Collection. American Heritage Center Laramie, WY.

Medicine Bow National Forest. 1924. Forest Protection Week and its Connection with the Medicine Bow National Forest. Prepared by the the United States Forest Service, Laramie, WY Medicine Bow collection American Heritage Center, Laramie, WY.

Mullison, J.H. and P.S. Lovejoy. 1909. **History of the Cheyenne National Forest.** Unpublished Administrative Report on file - Medicine Bow Collection American Heritage Center University of Wyoming, Laramie, WY.

Saratoga Sun and Platte Valley Lyre. Feb. 15, 1894. Quoted in Feb. 15, 1934 issue of the Saratoga Sun. "Forty Years Ago ...In

Saratoga.... Medicine Bow Collection. American Heritage Center Laramie, WY.

Smith, F. 1924. Handwritten statement to Medicine Bow National Forest regarding early fires. Medicine Bow Collection - American Heritage Center, Laramie, WY.

Thybony, S., Rosenberg, R.G. and E.M. Rosenberg. 1986. **The Medicine Bows: Wyoming's Mountain Country.** Caxton Printers, Ltd. Caldwell, ID.

USFS. Date??. Written report entitled "The Medicine Bow National Forest" documenting a field trip over the Happy Jack Road by the National Editorial Association in the mid-1920s. Medicine Bow Collection American Heritage Center, Laramie, WY.

Wood, D. 1995. Personal communication.

TABLE AP15.1 **Number of fires, cause and acreage burned - Medicine Bow National Forest. 1945-1993**

Area	Lightning		Man-Caused		Total
Sierra Madre					
Number	68	48%	73	52%	141
Acres	112 ac	7%	1472 ac	93%	1584 ac
Medicine Bow					
Number	167	32%	349	68%	516
Acres	1315 ac	11%	10859 ac	89%	12174 ac
Sherman Hills					
Number	47	48%	50	52%	97
Acres	21 ac	49%	21 ac	51%	42 ac
Laramie Mountains					
Number	605	85%	106	15%	711
Acres	12574 ac	84%	2482 ac	16%	15056 ac
TOTAL					
Number	887	61%	578	38%	1465
Acres	14022 ac	49%	14834 ac	51%	28856 ac

TABLE AP15.2 **Number and per cent of fires by size class and cause**
LC = lightning-caused MC = man-caused

Area	A	B	C	D	E	F	Total
SIERRA MADRE							
LC	55	12	1	0	0	0	68
	81%	18%	1%	-	-	-	
MC	54	8	5	6	0	0	73
	74%	11%	7%	8%	-	-	
Total	109	20	6	6	0	0	141
	72%	13%	4%	4%	-	-	
MEDICINE BOW							
LC	127	31	5	3	1	0	167
	76%	19%	3%	2%	.5%	-	
MC	252	70	19	3	4	1	349
	72%	20%	5%	.8%	1%	.2%	
Total	379	101	24	6	5	1	516
	73%	20%	5%	1%	1%	.2%	
SHERMAN MTS							
LC	44	3	0	0	0	0	47
	94%	6%	-	-	-	-	
MC	47	3	0	0	0	0	50
	94%	6%	-	-	-	-	
Total	91	6	0	0	0	0	97
	94%	6%	0	0	0	0	
LARAMIE MTS							
LC	364	212	15	5	8	1	605
	60%	35%	2%	.8%	1%	.2%	
MC	70	26	4	4	1	1	106
	66%	25%	4%	4%	1%	1%	
Total	434	238	19	9	9	2	711
	61%	33%	3%	1%	1%	.2%	
TOTALS							
LC	590	258	21	8		1	887
	66%	29%	2%	9%	9%	.2%	
MC	423	107	28	13	5	2	578
	73%	19%	5%	2%	.8%	.2%	
Total	1013	365	49	21	14	3	1465

TABLE AP15.3 Number of fires by elevation classes

Elevation	Number of fires	Per cent of fires
5500	2	<1%
6000	153	10%
6500	136	9%
7000	235	16%
7500	81	5%
8000	222	15%
8500	198	14%
9000	278	19%
9500	68	5%
10,000	65	4%
10,500	17	1%
11,000	10	1%
Total	1465	

TABLE AP15.4 Fire occurrence standardized to fires/million acres

Area	LC	MC	Total
Sierra Madre Mountains			
West	41	47	88
East	140	151	290
Sum	181	198	379
Medicine Bow Mountains			
North	169	370	539
South	154	295	449
Sum	323	666	989
Sherman Mountains	839	893	1732
Laramie Mountains			
North	359	70	429
South	987	170	1157
Sum	1346	241	1587

TABLE AP15.5 Number of fires, acres burned, fires/MM ac and acres burned/MM ac by size class and cause

Size	Number of fires	Number/ MM ac	Acres burned	Ac burned/ MM Ac
Sierra Madre Mts.				
Lightning Caused				
A	55	151	8	19
B	12	33	60	164
C	1	3	45	123
D	0	0	0	0
E	0	0	0	0
F	0	0	0	0
SUM	68	186	112	307
Man-Caused				
A	54	148	7	19
B	8	22	40	110
C	5	14	225	617
D	6	16	1200	3288
E	0	0	0	0
F	0	0	0	0
SUM	73	200	1472	4033
TOTALS	141	386	1584	4340
Medicine Bow Mts.				
Lightning-Caused				
A	127	239	15	28
B	31	58	155	291
C	5	9	225	423
D	3	6	600	1128
E	1	2	320	602
F	0	0	0	0
SUM	167	314	1315	2472
Man-Caused				
A	252	474	32	60
B	70	132	350	658
C	19	36	855	1607
D	3	6	600	1128
E	4	8	7774	14615
F	1	2	1250	2350
SUM	349	656	10859	20415
TOTALS	516	970	12174	22887

TABLE AP15. 5 (CONTD) Number of fires, acres burned, fires/MM ac and acres burned/MM ac by size class and cause

Size	Number of fires	Number/ MM ac	Acres burned	Ac burned/ MM Ac
Sherman Mountains				
Lightning-Caused				
A	44	786	6	107
B	3	54	15	268
C	0	0	0	0
D	0	0	0	0
E	0	0	0	0
F	0	0	0	0
SUM	47	840	21	375
Man-Caused				
A	47	839	6	107
B	3	54	15	268
C	0	0	0	0
D	0	0	0	0
E	0	0	0	0
F	0	0	0	0
SUM	50	893	21	375
TOTALS	97	1733	42	750
Laramie Mts.				
Lightning-Caused				
A	364	826	46	104
B	212	481	1060	2406
C	15	34	675	1532
D	5	11	1000	2270
E	8	18	5343	12129
F	1	2	4450	10102
SUM	605	1373	12574	28542
Man-Caused				
A	70	159	9	20
B	26	59	130	295
C	4	9	180	409
D	4	9	800	1816
E	1	2	390	885
F	1	2	973	2209
SUM	106	241	2482	5634
TOTAL	711	1614	15056	34176
Medicine Bow National Forest Totals (Approximate)	1465	4703*	28858	*

*These figures are somewhat inflated because the rounded approximation of acres for the subunits totals about 1.3 million acres (GIS estimates). Forest Plan total acreage ==1.09 million ac.

TABLE AP15.6 **Summary by fire size class, number of fires and acreage burned estimate**

Size Class	Number of fires	Per cent	Acres	% Acres
A	1013	69%	127	.4%
B	365	25%	1825	6%
C	49	3%	2205	8%
D	21	1%	4200	15%
E	14	.9%	13,727	48%
F	3	.2%	6,673	23%
Total	1465		28,757	

TABLE AP15.7 CLASS E FIRES

AREA	Name	Cause	Date		Total Acres	NFS Ac
SNOWY RANGE						
BRUSH CREEK DIST.						
Snowy Range North						
	Rock Creek	MC	07/06/55		3232	2104
	Lincoln Creek	MC	07/09/55		2972	1486
	Pass Creek	MC	07/12/69		1400	1383
LARAMIE DIST.						
Snowy Range South						
	Lewis Creek	LC	08/30/60		320	320
	Smith Creek	MC	10/06/64		170	160
				sum	8094	5453
LARAMIE RANGE						
DOUGLAS DISTRICT						
Laramie Mts. North						
	Latham Creek	MC	10/19/45		620	
	Deer Creek	MC	08/25/69		520	40
	W. Fk. Deer Cr	MC	09/11/62		E500	
Laramie Mts. South						
	Palmer Canyon	LC	07/05/54		390	20
	Bear Creek	MC	09/26/74		785	695
	Cottonwood Prk	MC	08/26/64		730	365
	Ballard	MC	10/23/50		229	127
	3 Cripples	MC	06/16/86		945	514
	Johnson	MC	05/04/48		914	733
				sum	5633	2454
				grand sum	13727	7907

TABLE AP15.8 CLASS F FIRES

AREA	Name	Cause	Date		Total Acres	NFS Ac
SNOWY RANGE						
BRUSH CREEK DISTRICT						
Snowy Range Nort						
	Barrett Ridge	MC	06/13/77		1250	1250
LARAMIE RANGE						
DOUGLAS DISTRICT						
Laramie Range South						
	Collins Creek	LC	07/26/86		4450	520
	Maggie Murphy	MC	09/02/56		973	755
				sum	5423	1275
				grand sum	6673	2525

TABLE AP15.9 Number of fires and acres burned on the Roosevelt, Routt and Medicine Bow National Forests (1960-1973). Per MM Ac.

FOREST	Number	Percent	#/ MM Ac	Ac burned/ MM Ac	% of total burned
Roosevelt*					
LC	230	48.7	212	357	8%
MC	242	51.3	224	4251	92%
Total	472		436	4608	
Routt*					
LC	68	35.6	55	439	47%
MC	123	64.4	99	489	53%
Total	191		154	928	
Medicine Bow					
LC	329	63.8	329	1576	29%
MC	186	36.1	186	3882	71%
Total	515		515	5458	

* Barrows and Ryan (1976)

TABLE AP15.10 Number of fires and acres burned on the Medicine Bow National Forest for the period 1960-1973. Per MM Ac.

AREA	Number	Percent	#/ MM Ac	Ac burned/ MM Ac	% of total burned
Sierra Madre					
LC	20	59%	55	7	1%
MC	14	41%	38	570	99%
Total	34		93	577	
Medicine Bow					
LC	61	34%	114	724	16%
MC	116	66%	218	3686	84%
Total	177		332	4410	
Sherman Mts.					
LC	19	58%	339	214	52%
MC	14	42%	250	196	48%
Total	33		609	410	
Laramie Mts.					
LC	229	85%	519	2145	33%
MC	42	15%	95	4370	67%
Total	271		615	6515	

Acreages: Sierra Madre - 365,000 ac; Medicine Bow Mts - 533,000 ac; Sherman Mts. - 56,000 ac Laramie Mts. - 441,000 ac

TABLE AP15.11 Number of fires by size class and cause for the Roosevelt, Routt and Medicine Bow National Forests

FOREST	Number(#) Per cent (%)	A	B	C	D	E	F	T
Roosevelt*								
LC	#	159	66	4	1	0	0	230
	%	69%	29%	2%	.4%	-	-	49%
MC	#	173	57	6	3	2	1	242
	%	72%	24%	3%	1%	.8%	.4%	51%
Total	#	332	123	10	4	2	1	472
	%	70%	26%	2%	.8%	.4%	.2%	
Routt*								
LC	#	57	9	0	1	1	0	68
	%	84%	73%	-	2%	2%	-	36%
MC	#	93	22	6	2	0	0	123
	%	76%	18%	5%	2%	-	-	64%
Total	#	150	31	6	3	1	0	191
	%	79%	16%	3%	2%	.5%	-	
Medicine Bow								
LC	#	234	88	10	2	1	0	335
	%	70%	26%	3%	.5%	.2%	-	65%
MC	#	140	28	5	2	5	0	180
	%	77%	16%	3%	1%	3%	-	35%
Total	#	374	116	15	4	6	0	515
	%	73%	23%	3%	.7%	1%	-	

*Barrows and Ryan (1976)

TABLE AP15.12 Fire occurrence by size class for the period 1960-1973 on the Medicine Bow National Forest

FOREST	Number(#) Per cent (%)	A	B	C	D	E	F	T
Sierra Madre								
LC	#	21	0	0	0	0	0	21
	%	100%	-	-	-	-	-	62%
MC	#	9	1	2	1	0	0	13
	%	69%	.8%	2%	.8%	-	-	38%
Total	#	30	1	2	1	0	0	34
		88%	3%	6%	3%	-	-	
Medicine Bow								
LC	#	47	12	0	1	1	0	61
	%	77%	20%	-	2%	2%	-	34%
MC	#	94	18	2	0	2	0	116
	%	81%	16%	2%	-	2%	-	66%
Total	#	141	30	2	1	3	0	177
	%	80%	17%	1%	5%	2%	-	
Sherman Mts.								
LC	#	17	2	0	0	0	0	19
	%	89%	11%	-	-	-	-	66%
MC	#	12	2	0	0	0	0	14
	%	86%	14%	-	-	-	-	44%
Total	#	29	4	0	0	0	0	33
	%	88%	12%	-	-	-	-	
Laramie Mts.								
LC	#	149	74	10	1	0	0	234
	%	64%	32%	4%	.04%	-	-	86%
MC	#	25	7	1	1	3	0	37
	%	68%	19%	3%	3%	8%	-	14%
Total	#	174	81	11	2	3	0	271
	%	64%	30%	4%	.7%	1%	-	

TABLE AP15.13 Fire occurrence by state (1960-1975)*

	Lightning		Man-Caused		Total
Idaho	17,423	66%	8,985	34%	26,408
Montana	11,377	64%	6,474	36%	17,851
Wyoming	3,375	46%	3,944	54%	7,319
Colorado	5,921	34%	11,287	66%	17,208
New Mexico	13,406	80%	3,323	20%	16,729

*Barrows (1978) page 3

TABLE AP15.14 Fire occurrence by state per MM/ac protected 1960-1975*

	Lightning	Man-Caused	Total
Idaho	398	206	604
Montana	278	158	436
Wyoming	93	109	202
Colorado	179	340	519
New Mexico	330	82	412

*Barrows (1978) page 4

TABLE AP15.15 Number of fires and area burned in Regions 1, 2 and 3 (1960-1975).
LC = lightning-caused
MC = man-caused*

	LC	%	MC	%	Total
R-1					
Number	15934	74%	5463	26%	21397
Area	225835 ac	71%	92566 ac	29%	318401 ac
R-2					
Number	5641	59%	3986	41%	9627
Area	69088 ac	50%	69607 ac	50%	138695 ac
R-3					
Number	29973	80%	7555	20%	37528
Area	383006 ac	76%	204084 ac	24%	507090 ac

*Barrows (1978) page 5

TABLE AP15.16 Number of fires by size class

	A	B	C	D	E+	F	Total
SE Region 1*							
(1946-1973)	1290	643	124	28	19		2104
28 years	61%	31%	6%	1%	.9%		
Colorado							
(1960-1973)**	1456	435	44	11	4	3	1953
14 years	75%	22%	2%	.5%	.2%	.2%	
Eastern Zone Region-3***							
(1960-1974)	3769	830	94	15	6	7	4723
15 years	80%	18%	2%	.3%	.1%	.1%	
Medicine Bow National Forest							
(1945-1993)							
49 years	1018	362	44	20	14	3	1462
	70%	24%	3%	1%	.9%	.2%	

SE-Region 1 = Beaverhead, Custer and Gallatin NF Colorado = Arapaho, Roosevelt, Pike, and Routt NF Eastern Zone Region-3 = Carson, Santa Fe, Cibola and Lincoln NF

* Barrows et al (1975)
** Barrows and Ryan (1976)
*** Barrows (1978)

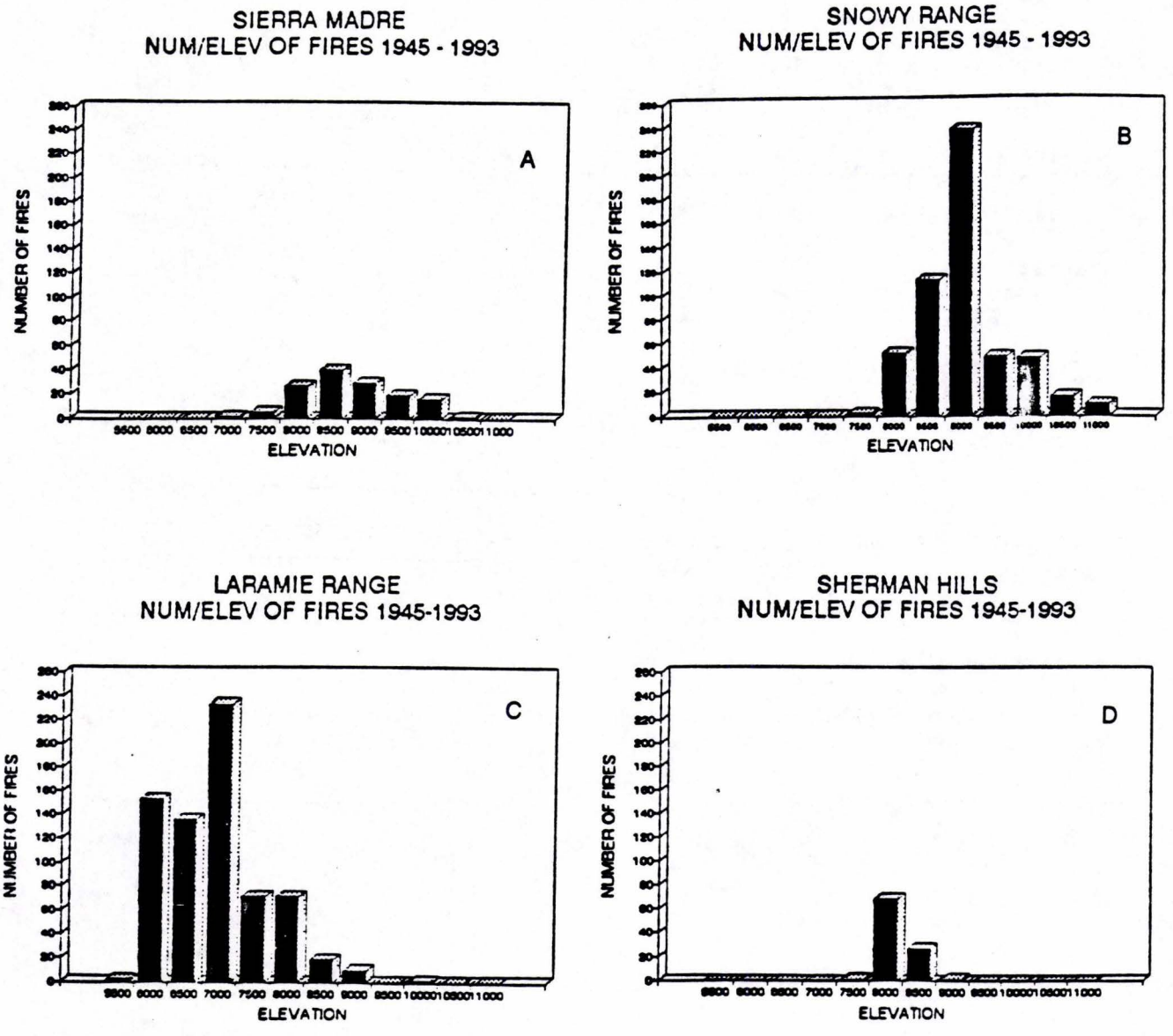


FIGURE AP15.1 Number of fires by elevation classes for each mountain range on the Medicine Bow National Forest.

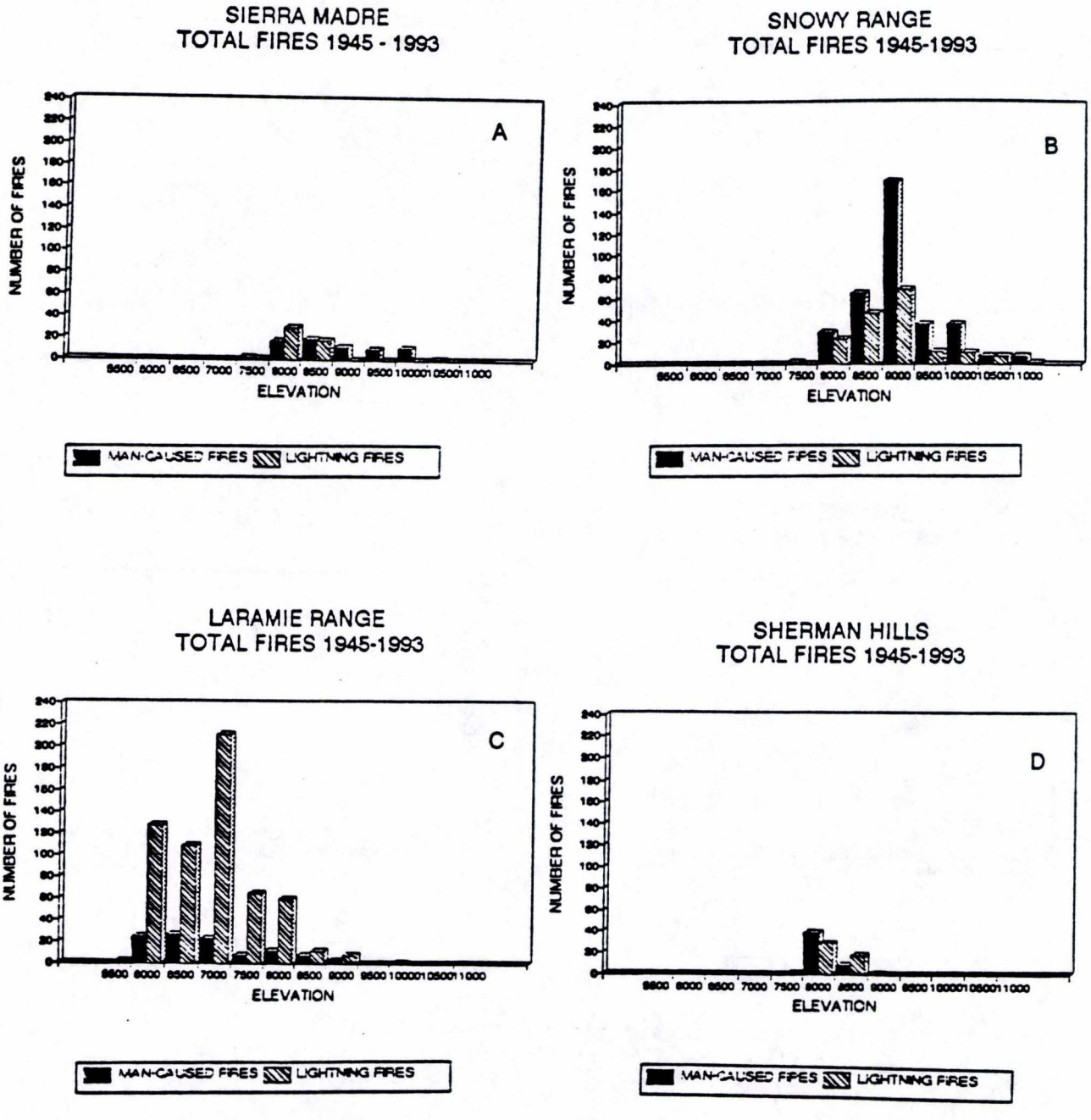


FIGURE AP15.2 Number of fires by elevation classes for subdivisions of mountain ranges (Sierra Madre east and west of the Continental Divide); Snowy Range North and South; Laramie Mountainws North and South; Sherman Mountains (not divided).

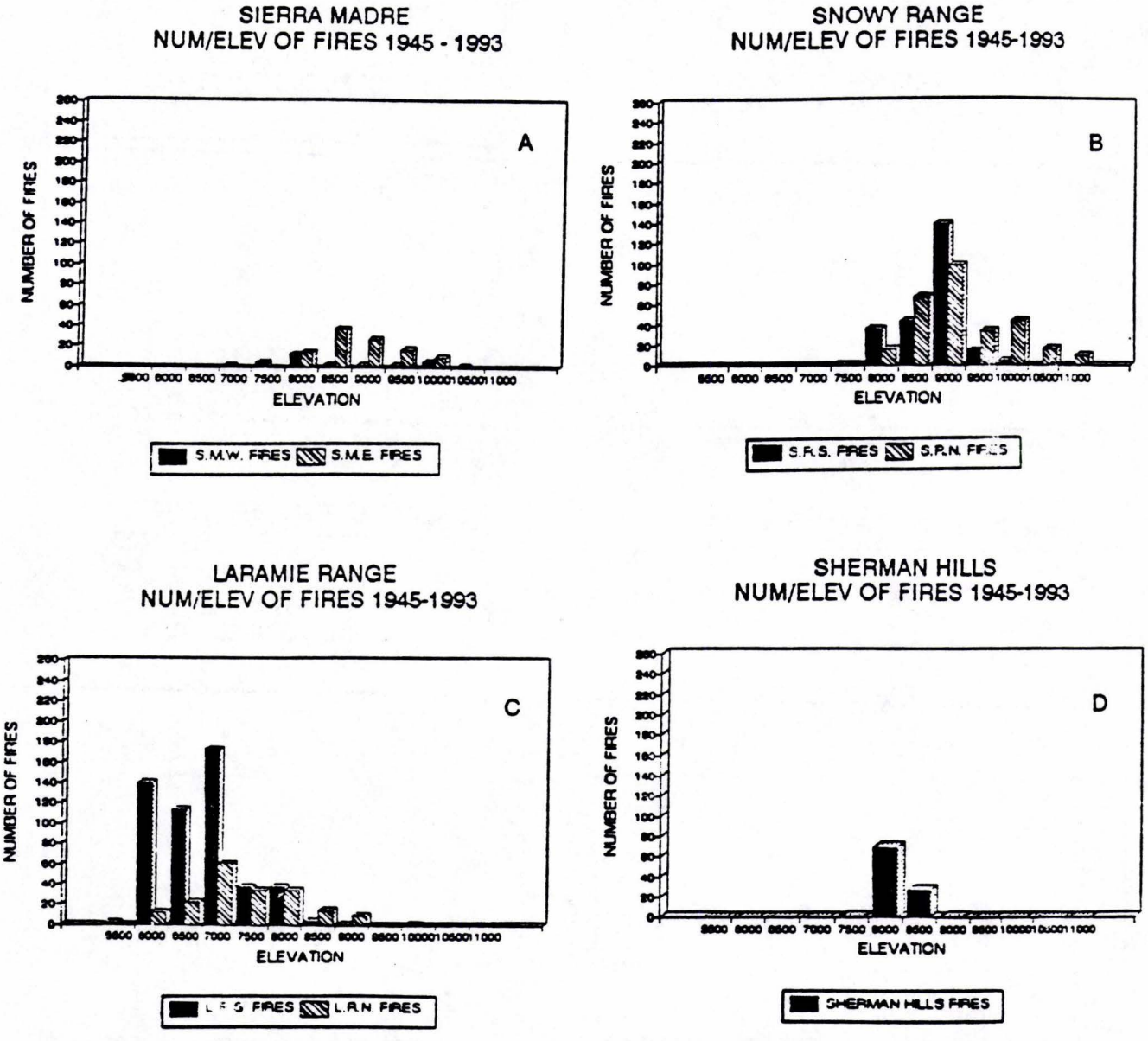


FIGURE AP15.3 Number of man-caused fires compared to lightning-caused fires, by elevation classes for each mountain range on the Mediicne Bow National Forest.

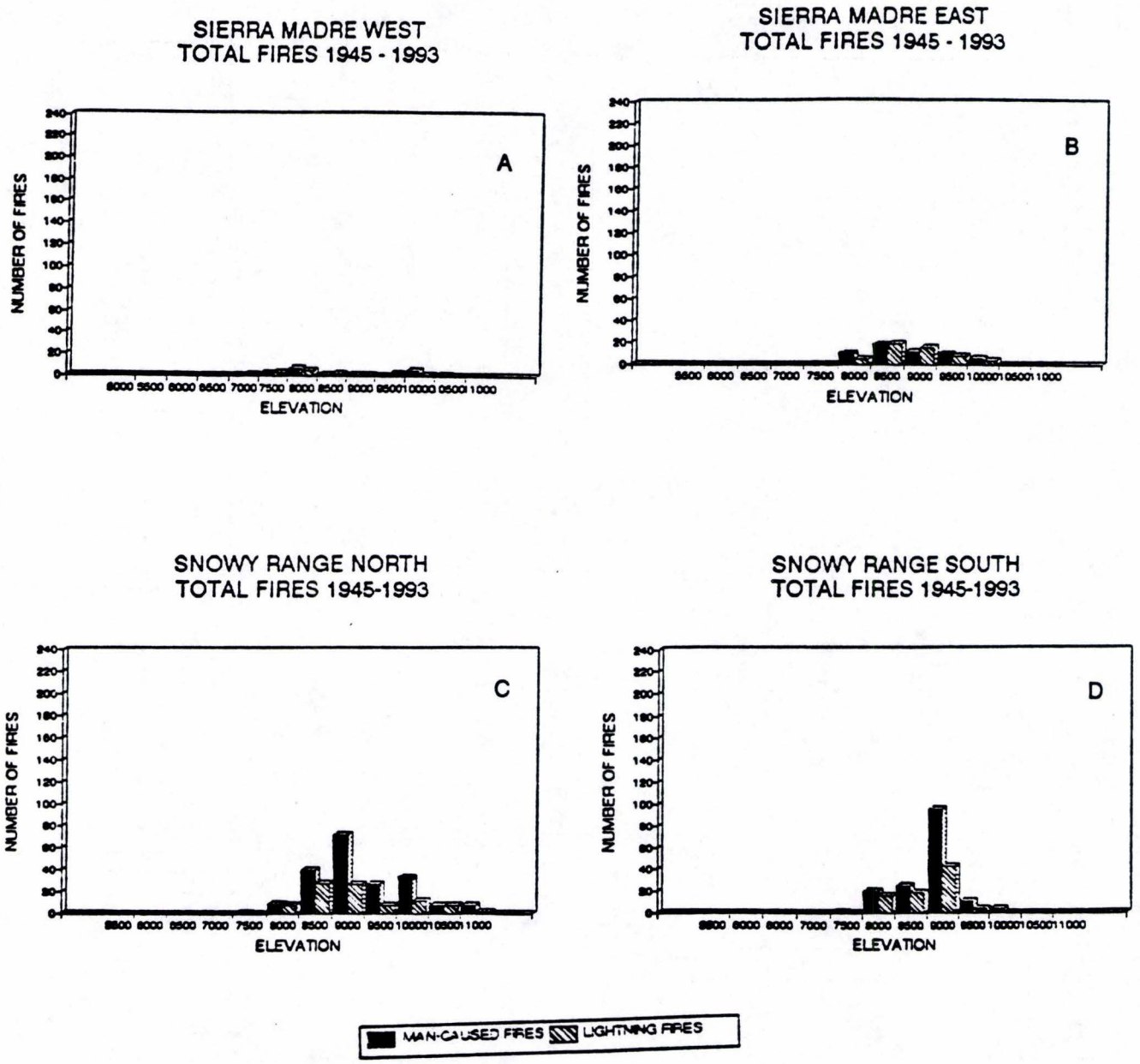


FIGURE AP15.4 Man-caused vs lightning-caused fires, by elevation class, for subdivisions of mountain ranges.

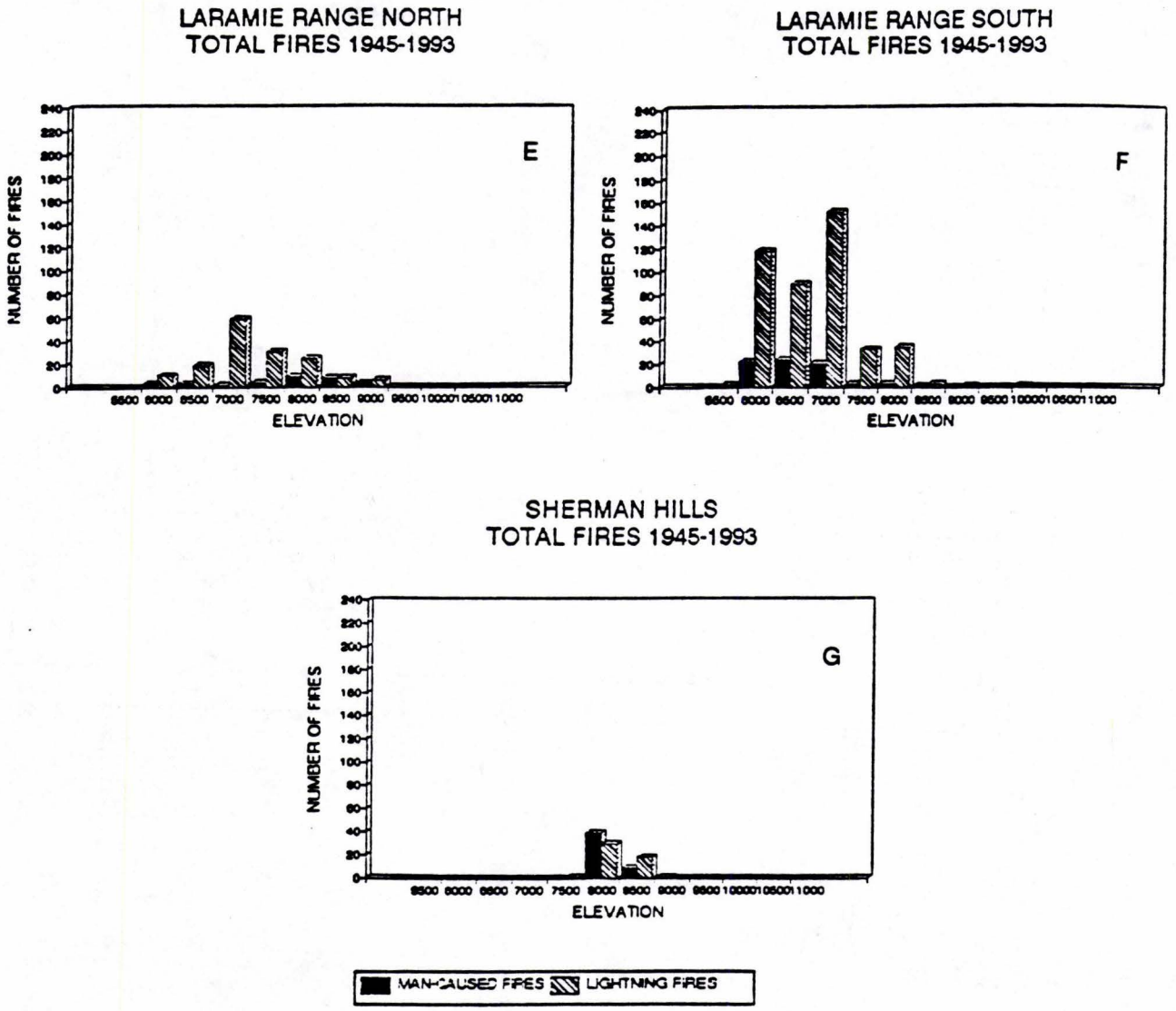


FIGURE AP15.4 Man-caused vs lightning-caused fires, by elevation class, for subdivisions of mountain ranges.

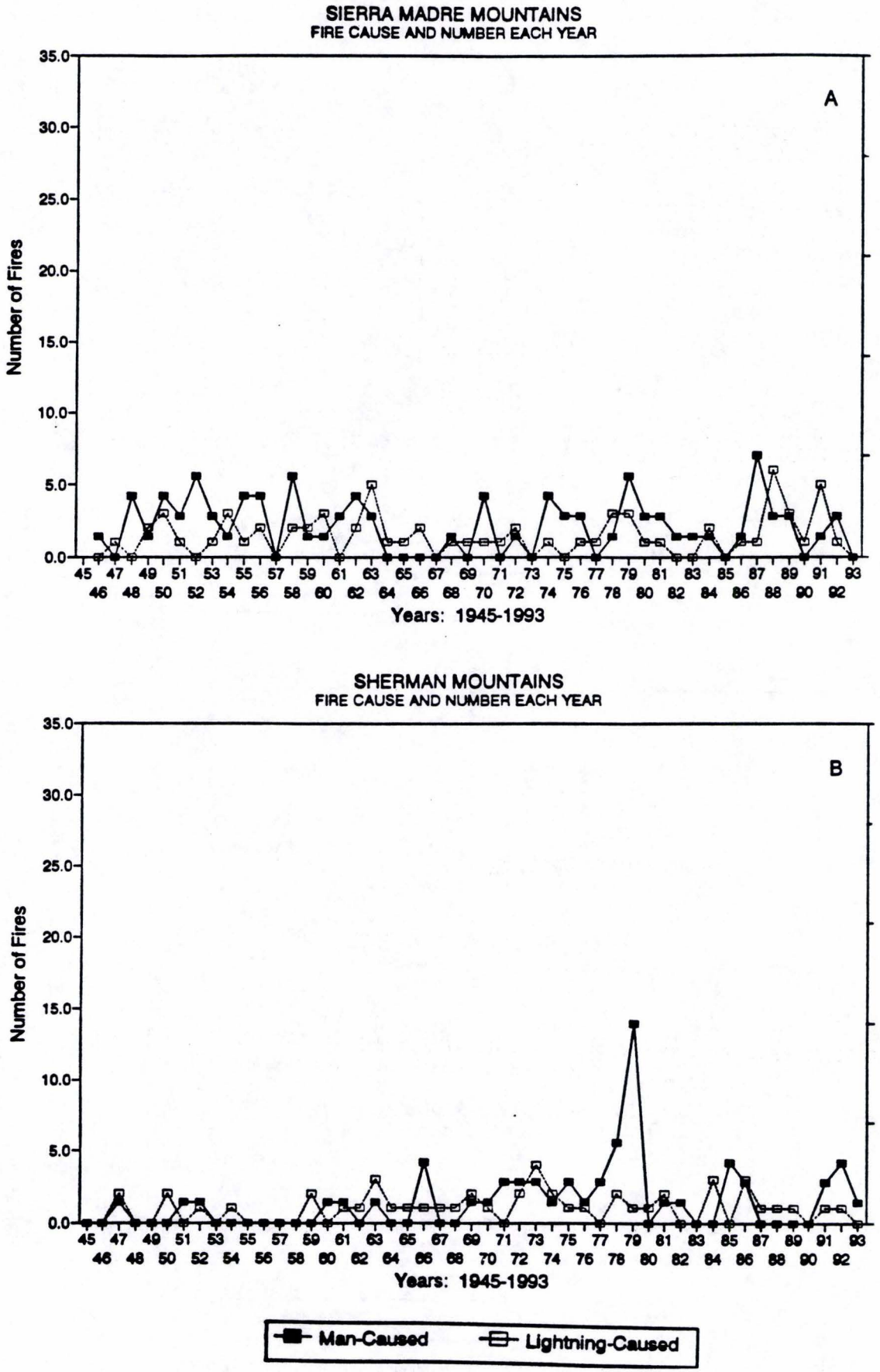
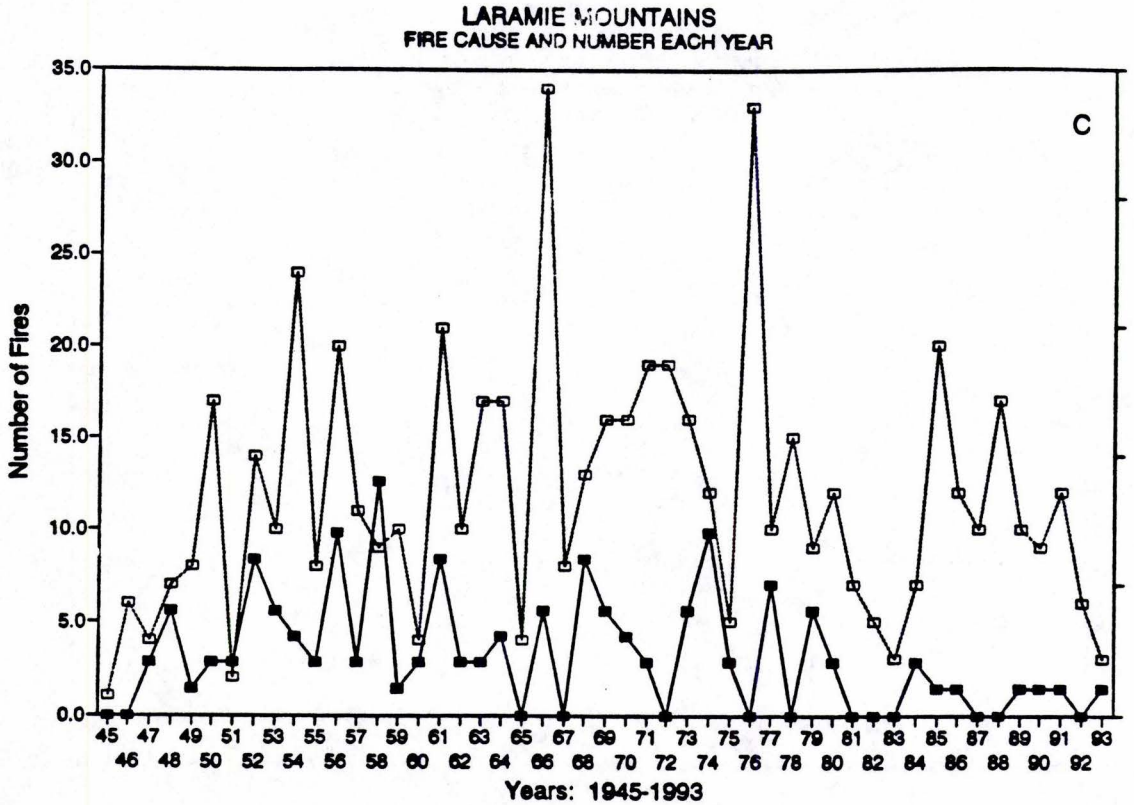


FIGURE AP15.5 **Yearly pattern of man-caused and lighting-caused fires by mountain range in the Medicine Bow National Forest.**



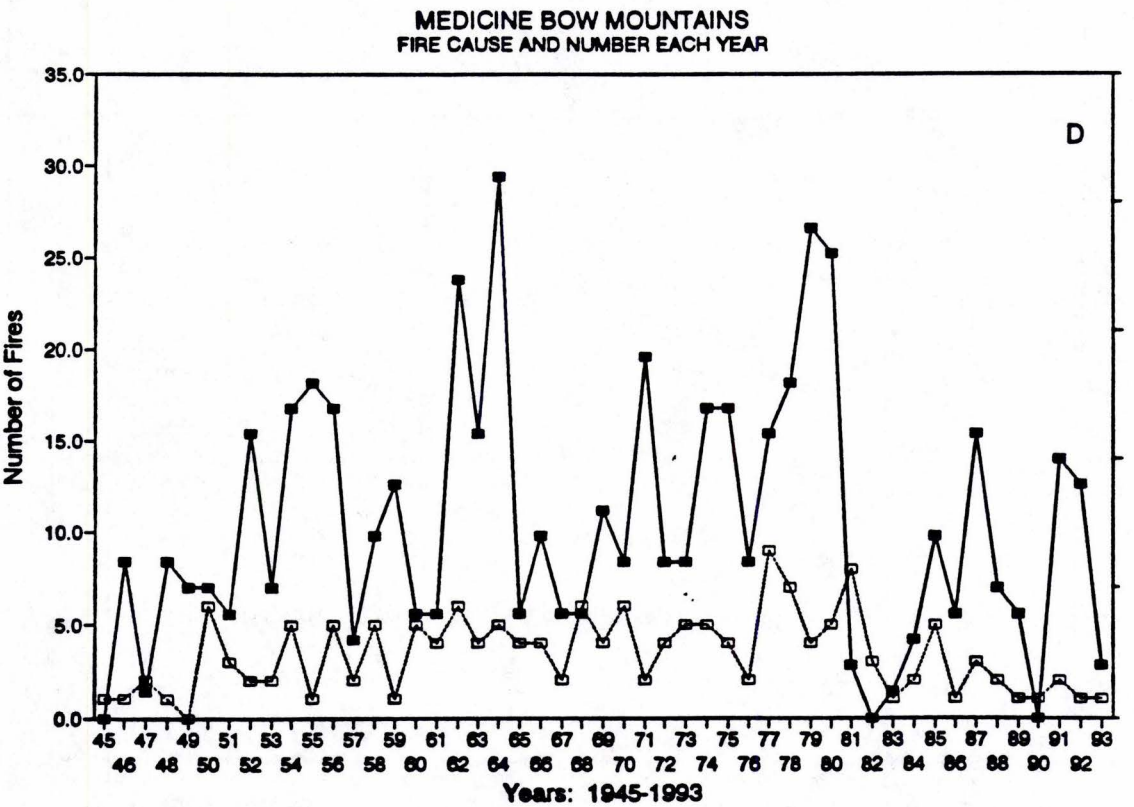


FIGURE AP15.5 Yearly pattern of man-caused and lighting-caused fires by mountain range in the Medicine Bow National Forest.

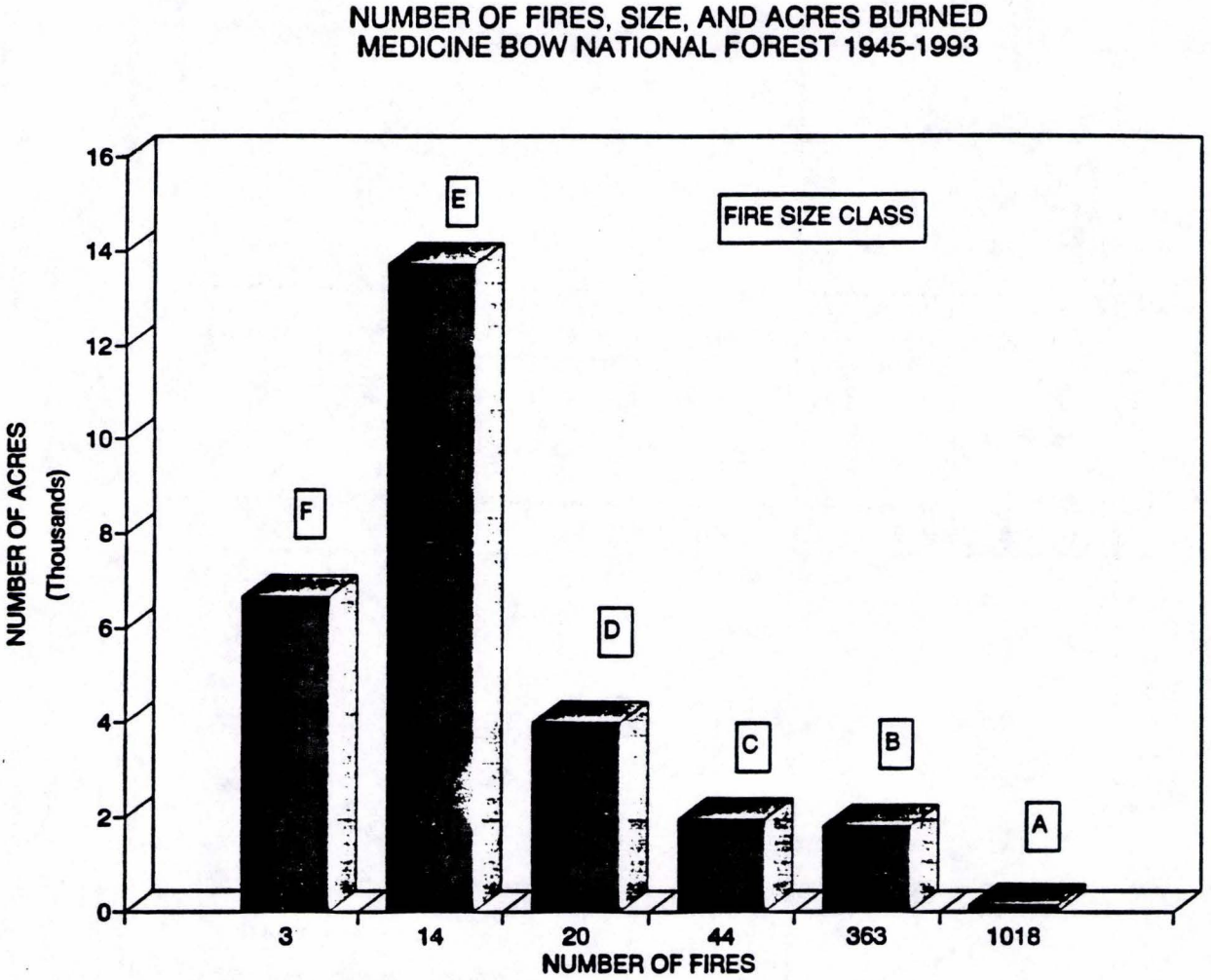


FIGURE AP15.6 Number of fires compared to acres burned for fires in each size class

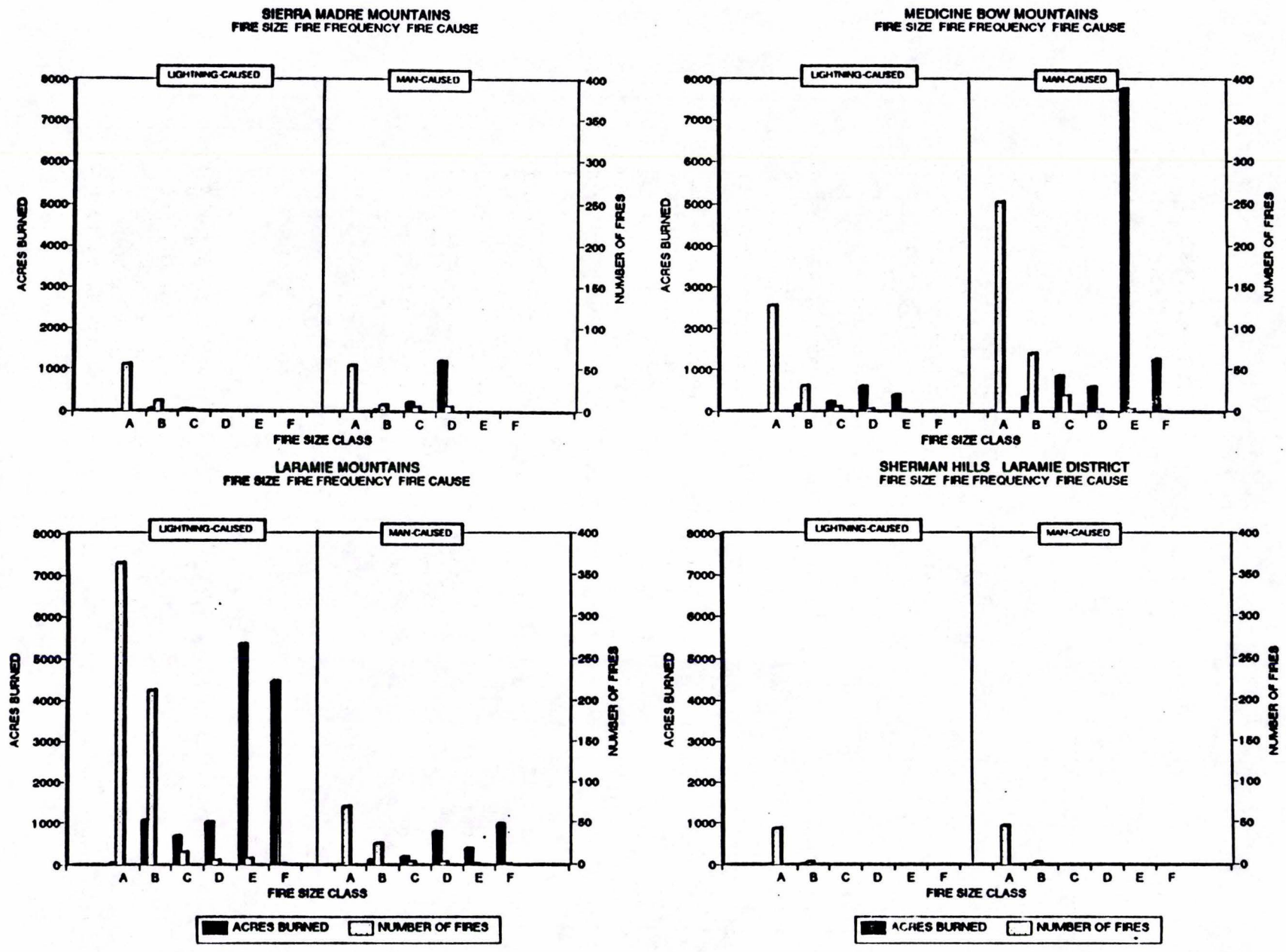


FIGURE AP15.7 Comparison of number of fires, acres burned and cause for each mountain range in the Medicine Bow National Forest.

APPENDIX 16

BIOLOGICAL DIVERSITY OF CLEARCUTS CREATED 1950 TO 1992 - MEDICINE BOW MOUNTAINS

PURPOSES OF THE STUDY

The main purposes of this study were to assess biological diversity of vascular plant species during succession in clearcuts spanning a 43 year period, and to compare composition and structure of these clearcuts with uncut stands of lodgepole pine and spruce-fir cover types. Secondary objectives were to ascertain levels of root colonization by ectomycorrhizal fungi in clearcuts and uncut forest. Infection rates by ericoid mycorrhizae of *Vaccinium* sp. were also investigated. Soil fertility was also measured.

Species composition and per cent cover of understory species of clearcuts in lodgepole pine and spruce-fir cover types in clearcuts from five time periods from 1950-1992. Understory species compostiona dn per cent cover were compared to sites containing old forest not entered for recent (since 1950) timber harvest. Field information included species composition and cover for vascular plants; and tree size, species and age. Soil samples containing conifer and **Vaccinium** roots for mycorrhizal analysis and all fungal sporocarps within the sample plots were collected. Lichens were collected the following summer from twenty five stands. Lichens are discussed in Appendix 7.

Forest Service monitoring requirements are concerned only with tree regeneration success within 5 years of clearcut harvest. No other measurements of plant community development are tracked in the Rocky Mountain Resource Information Database (RM-RIS). This study provided information about what kinds of biological diversity develop in clearcuts following timber harvest and post harvest treatment (piling and burning, rollerchopping, precommercial thinning). Measurements of plant community charactersitics were taken during the summer of 1993.

FIELD METHODS

The field work was done from June 14 - August 28, 1993. Sixty-five sites were chosen from lists generated from the RM-RIS database showing cover type, year cut and year of origin. Clearcut sites were chosen to represent, when possible, the first three years of each decade (1950's - 1990's), so there was a minimum of 7-13 years difference among most site ages. Both strip cuts and block cuts of different sizes were included in the sample.

Another criterion was to choose sites on widespread landtypes between 8500 and 10,600 feet in elevation. Restricting sites to a limited array of widespread landtypes reduced some of the variation introduced by different soils. The landtypes chosen (sensu Landtype Associations, Marston, 1988) are shown in Table AP16.1. These are typical of the most areas affected by clearcutting since 1950. Site locations are shown in Figure AP16.2. Upland sites were chosen for this study, but riparian patches occur ubiquitously in some sites, especially at higher elevation, because of springs.

Corners of a 50m x 50m large plot was marked with surveyors tape. Ocular estimates per cent cover of all vascular plant species present were recorded using categories of: trace, less than 1%, and thereafter the nearest 5%. A 20m x 50m macroplot was positioned astride a center transect of the 50m large plot. Within the macroplot, numbers of individuals of each tree species and size class were counted to determine species composition, size class and density. Along the center transect, 10 Daubenmire quadrats were read at five meter intervals as a check on ocular estimate figures.

Soil samples, which included conifer and *Vaccinium* roots were taken adjacent to Daubenmire quadrats 2, 4, 6, 8 and 10. Soil samples were placed into standard soil-sample bags, labeled and kept in a cooler in the field. Fungal sporocarps were collected in the 50 x 50 meter plots. Soil and fungal samples were cold-stored (about 1°C, 34°F) until analysis. Mycorrhizal work was done cooperatively through the Department of Plant, Soil and Insect Sciences (Stephen E. Williams and Zhipeng Zhao) of the University of Wyoming. Soil physical and chemical analysis was done in conjunction with Masters thesis work by Vicki Whitten-Dowse, Department of Geography and Recreation, University of Wyoming.

Lichens were collected from 24 of the sample sites during August and September 1994. Steve Chumley, University of Wyoming student, assisted in the identification of lichens to genus.

It was not possible to control several important variables in stand selection. One was livestock grazing, another was post-harvest treatment and a third was influence from tie-hacking prior to 1900. All sites were in active grazing allotments that are used for summer pasture. Most stands were near roads which provided access by cattle. Regenerating clearcut stands with a significant grass/forb component are considered transitory rangeland and are available to cattle and sheep. Most stands were in cattle allotments.

The RIS database had post-treatment information for thinning since 1980 and rollerchopping. There were no records of post-harvest treatment prior to 1980, but bulldozer piling and burning was the most common method of slash disposal from 1950-1980. Rollerchopping

has been a widespread post-harvest treatment since the late 1970s. Deeply heated soils have low level of biological activity (Christensen et al, 1989). Surface deposites of charcoal and soil discoloration mark these areas which were evident in most clearcuts used in the study. These areas were avoided for data collection.

Site number 8 (Group 3) appeared to have been broadcast burned. Most stands cut in the 1950 - 1963 had been thinned between 1982 and 1985. Some stands cut in 1970-71 had been thinned in 1991-92, other stands cut in the early 1970s had not been thinned. All stands cut in the 1990s had been rollerchopped. Some 1980s cuts had been rollerchopped, and others had undetermined post-harvest treatment. Tie-hacking effects in all control stands were minimal to absent.

DATA ANALYSIS METHODS

Data was analyzed usng several methods:

1. species were tallied for each stand to determine species richness and constancy among stands

2. pattern in the percent cover of understory shrubs, forbs and grasses was determined using CANOCO (Canonical Correspondence Analysis) Ter Braak (1986).

3. mycorrhizal analysis consisted of measuring:
   a. number of conifer root tips infected with ectomycorrhizae per milliliter of soil
   b. the percentage of **Vaccinium** root tips with endomycorrhizal infection.
   (Grand and Harvey, 1982)

4. tree composition of regenerating clearcuts was tallied by stand to determine the number of seedlings, saplings, poles and mature trees for lodgepole pine, subalpine fir, Engelmann spruce and aspen and tree density (trees/acre).

5. soil physical and chemical analysis was done by Vicki Whitten-dowse and the U. WY. Soil Analysis Laboratory for Masters thesis data.

The ordination of understory species (#2 above) indicated that some of the sites contained redundant information so 12 sites were omitted from further analysis, leaving a total of 53 sites in the data group.

RESULTS

1. species richness

There were 181 vascular plant species in 65 stands. This includes several unknowns which were found consistently in the stands, but were unidentifiable. Identified species are listed in Table AP16. 3. If the plant was identified only to genus, the genus name is used in this report. Acronyms (Table AP16.3) are for plants identified to species.

2. pattern among stands

Canonical correspondence analysis was done using the per cent cover of understory shrubs, forbs and grasses for each site as vegetation variables. The per cent infection of *Vaccinium* roots with endomycorrhizae (VACC) and the conifer ectomycorrhizal root tips/ml of soil (ECM) were used as environmental variables in the analysis. The results are presented in Figure AP16.2, a biplot diagram which shows the relationships among the stands as they are arranged along gradients represented by Axis 1 and Axis 2. Axis 1 is a moisture gradient and is closely related to the percent cover of *Vaccinium* and graminoids. Axis 2 is an elevation gradient related to the presence of spruce-fir and lodgepole pine forest with associated understories of tall shrubs or *Vaccinium*.

The biplot shows the pattern present in the understory vegetation data. There are 11 Ordination Groups shown in Figure AP16.2. Groups 1-4 represent lodgepole pine cover types; Groups 5-11 represent spruce-fir cover types or lodgepole cover types in very late successional stages containing a lot of Engelmann spruce and/or subalpine fir. Groups 10 and 11 contain many riparian species and represent spruce-fir cover types which occur on high elevation sites with springs. Tables AP16.3 and AP16.4 provide further detail as to the tree, shrub, forb and grass composition of these groups with regard to per cent cover of major species.

Table AP16.4 shows the pattern of shrub presence in 11 Groups identified by the CANOCO analysis. The list of species is arranged in general descending occurrence by elevation. Table AP16.5 shows the species pattern of the most common shrubs, forbs and grasses in the eleven ordination groups. If no percentage is given after the genus or acronym in Table AP16.5, then that component was present as less than 1% cover. Refer to Tables AP16.4 and AP16.5 for details supporting the following descriptions.

Within the lodgepole pine ordination groups (1-4); Group 1 represents stands with a substantial component of tall understory shrubs such as russett buffaloberry, common juniper, currant and wild rose. *Vaccinium* is present but not dominant. These stands

include the control stands and stands cut mostly in the 1950s. Shrub presence decreases from left to right along Axis 1, while presence of graminoids (especially elk sedge and Ross sedge) and forbs increases.

Groups 2-4 include stands cut in the 1960s-1990s. *Vaccinium* has a low percent cover or is absent from Groups 2-4. Groups 2 and 3 have a substantial percent cover of lupine, a nigrogen-fixign leguminous forb. Group 3, represents warm sites with thin soils. Kinnikinnk is characteristic for these sites. Group 4 is "weedy' with species such as bottlebrush squirreltail, barley, and thistle.

Within the spruce-fir Ordination Groups (5-11); Group 5 represents the control stands which range in age from about 1780 to 1900. These stands have in common a high percentage of *Vaccinium* in the understory but are quite variable in shrub, forb and graminoid composition. Species other than *Vaccinium* tend to associate with small disturbance areas (gaps). Similar to the lodgepole Ordination Groups, the per-cent cover of *Vaccinium* decreases across Axis 1 from left to right. There is an accompanyng increase in diversity of shrubs from left to right along Axis 1, but there is not a substantial increase in per cent cover of graminoids although there are more species in the groups at the right end of Axis 1. Groups 8 and 9 in the spruce-fir category are also "weedy" in the sense of supporting thistle, dandelion and annual forbs. Groups 8 and 9 have the highest number of species of forbs as well as the most per cent cover of forbs.

The arrows in Figure AP16. 2 point in the direction of increasing amounts of conifer ecotomycorrhizae or increasing per cent infection of *Vaccinium* roots with endomycorrhizae. *Vaccinium* occurred in all spruce-fir stands and had high percent cover in the contol stands and stands cut 1950-1963. However *Vaccinium* formed appreciable cover only in Groups 1 and 2 for lodgepole pine. *Vaccinium* was barely present in Groups 10 and 11 which are high elevation spurce-fir stands on sites with springs cut in the 1970s.

3. Mycorrhizal and fungal sporocarp analyses

Figures AP16.3 and AP16.4 show the correlation analysis of the mean Axis I group ordination value with mycorrhizal infection data values. Figure AP16.3 shows the mean Axis 1 group ordination value plotted against mean tips/ml of soil for conifer ecotmychrrhizae in each group. Figure 4 shows mean Axis 1 group ordination values vs mean per cent infection of *Vaccinium* roots in each Group. The R-squared value (correlation) for conifer ectomycorrhizae and Ordination Axis 1 is 0.73. It is 0.21 for *Vaccinium* ectomycorrhizae values and Ordination Axis 1.

The gradient of ectomycorrhizal presence in these stands increases from right to left along the X-Axis, and from bottom to top on the Y-Axis. Spruce-fir stands at high elevations had consistently high tips/ml soil ECM values and the percent of Vaccinium roots with endomycorrhizae was 65% or more. The percent cover of *Vaccinium* was also high in groups 5-7. Lodgepole pine stands had lower ectomycorrhizal tips/ml amounts and variable presence of *Vaccinium*. Groups 10 and 11 (wetter sites) had low values for both per cent *Vaccinium* infection (due to lack of *Vaccinium* in these stands) and also low tips/ml soil ECM values.

Ectomycorrhizae of three different morphological types were found on the conifer roots (black, white and golden-yellow). This is a low diversity of mycorrhizae compared to the Pacific Northwest. Ectomycorrhizae of *Vaccinium* roots were also of three kinds, typical of mycorrhizal species associated with plants in the Family Ericaceae (Zhao, 1995).

Table AP16.2 lists the kinds of fungal sporocarps (fruiting bodies) found (Zhao, 1995). Most fungi occurred in the uncut forest or in regenerating forests cut in the 1950s and 1960s. Fungal sporocarps are often the vegetative reproductive organ of ectomycorrhizal fungi. While their presence indicates the presence of mycorrhizal speciss, the absence of sporocarps is inconclusive regarding the absence of mycorrhizae because environmental conditions may not be right for sporocarp development.

4. Stand Structure - Tree species, size and density

Density of trees per acre was calculated from counts of tree species in seedling, sapliong, pole and mature size classes in the 20x50 meter macroplot. Figures AP16.5, AP16.6 and AP16.7 sho values for six of the ordination goups. Groups 1 and 5 (Figure AP16.5) represent the composition of species and age classes for the uncut/1950s cut lodgepole stands and the uncut spruce-fir stands. Dominance of lodgepole and fir seedlings is opposite in these stands. Spruce seedling density is much less than fir in Group 5. Group 6 and 7 (Figure AP16.6) represent clearcuts since 1950. Group 6 has predominantly lodgepole pine, while group 7 is dominated by fir seedlings, nearly 2:1 over lodgepole pine. The only group in which speuce is well-represented in seedling/acre is Group 11 whcih was a high elevation riparian group. It appears that it will be a long time befores spruce is an important component in regenerated forests.

Figure AP16.5 shows the patterns of tree species, size and density (trees/acre) for all ordination groups.. Each set of bars represents trees/acre with (left to right) seedlings, saplings, poles, and mature trees. This information is arranged using the

ordination diagram with stand group positions determined by understory species.

In Figure AP16.5, ordination Groups 5 and 6 have a predominance of fir seedlings. Group 5 is the control, the classic spruce-fir forest with more mature spruce than fir but more fir in the understory. There is a minor lodgepole component. Group 6 contains mainly spruce-fir stands cut in the 1950s or early 1960s. There are few mature trees, but a strong pole component, especially for lodgepole pine and fir.

Groups 1, 2, 3, 4 and 7 have a predominance of lodgepole seedlings with a substantial subalpine fir seedling component. All of these groups generally are found at lower elevations than Groups 5 and 6. Spruce is beginning to appear in Group 1 (primarily uncut lodgepole sites, or sites cut in the 1950s.)

Groups 8 and 9 (which contain most of the 1990s clearcuts) have more fir than lodgepole pine seedlings. Spruce seedlings are sparse. Groups 10 and 11 are the only ones with a major spruce seedling component. Group 10 (9900-10,200 feet) consists of stands growing on high-elevation sites with patchy wet-dry areas. Group 11 has a high spruce seedling population because of elevation (9900-10,400 feet), the presence of springs which make the site fairly wet. The elevation also limits the lodgepole pine seed source and regeneration capacity.

It is noteworthy that stands harvested by clearcutting in the 1950s and 1960s have a present component of mature spruce and/or subalpine fir. This is because submature trees were left in the cut areas. Rollerchopping was not used as a post-harvest treatment method during those years. Silviculture practices in the last 20 years have left few if any submature spruce or fir trees in the clearcuts. Instead, standing dead trees (snags) have been left.

5. Soil properties

Soil organic matter, litter and duff measurements were completed, but there was little correlation of these properties with any of the other data. For this report, a brief, preliminary analysis which places the soil chemical results in Ordination Groups is presented in Figures AP16.9 and AP16.10. These show the pattern of occurrence of calcium (meq/100g), magnesium (meq/100g x 10) and phosphate from 5 soil samples from stand as arranged by the means of groups of stands within each Ordination Group.

Values for calcium were quite variable among samples within stands as well as among stands in groups. Magnesium values were less variable than calcium. Phosphate values were fairly consistent

among the samples for each stand, but there was a moderate of variation amng stand values in each ordination group. Although the correlation of soil chemistry values with the Ordination Axes was poor, examination of Figures AP16.9 and AP16.10 suggest some patterns.

Among the lodgepole pine stands (Groups 1-4) there was little overall difference between the uncut-1950s clearcut group (Group 1) and the other three groups for any of these soil chemicals. In contrast, the uncut, old spruce-fir forests (Group 5) had high values of magnesium (note that these are x10 on the graph so they can be seen), compared to Groups 6-9. A generally opposite trend occurred with phosphorus with the lowest ppm values in the old, uncut forests and the highest amounts in the disturbed sites. Groups 10 and 11 were high elevation sites with springs. All four sites in these two groups were clearcut in the early 1970s. These two groups had a small sample size (two sites each) and for that reason the data may be unrepresentative, especially the high magnesium value for Group 11.

This preliminary analysis only compares the soil chemical properties relative to the understory ordination groups. Vicki Whitten-dowse will be doing further data analysis for her Master's thesis.

DISCUSSION

The results of this study provide information on some of the biological diversity variation which is occurring both above and belowground as succession proceeds after clearcut harvest in lodgepole pine and spruce-fir forests. Although most of the measurements taken provided information for describing patterns in composition and structure, some inferences can be made regarding processes and functions in these systems.

1. Composition

a. Four lodgepole pine groups are present:
   Group 1 - tall lodgepole pine overstory with an understory of large shrubs such as buffaloberry, juniper, currant and wild rose. Warm, low elevation sites.

   Group 2 - Tall to medium sized lodgepole pines with mainly *Vaccinium* and commmon juniper in the understory. These are at higher elvations or cooler sites than Group 1.

   Group 3 - these stands are on poorer soils, and warm or windy areas. Although lodgepole pine predominates, limber pine may be

present and the major understory shrubs are kinnikinnik and wild rose.

Group 4 - the tree component is similar to group 3 but the understory is primarily grasses and sedges. These occur mostly at lower elevations (to about 9200 feet).

b. Four spruce-fir groups are present:

Group 5. Old, uncut spruce-fir forest forms a distinct group. This group has the fewest vascular plant species, but is the richest in mycorrhizae and lichen flora (see Appendix for lichen information). *Vaccinium* cover may be as high as 75% of the understory area. These are all above 9100 feet.

Group 6. Spruce-fir stands cut in the 1950s or 60s. These have spruce and fir components similar to Group 4, but have some lodgepole pine. Species richness is greater than for Group 4. *Vaccinium* cover is less (up to 15%) and there are other high elevation shrubs such as alpine currant and *Pyrola*.

Groups 10 and 11. High elevation wetter sites (springs are present) and are the only groups with significant cohorts of spruce seedlings. These are found within a few hundred feet of timberline.

c. Three mixed spruce-fir and lodgepole pine groups are present:
Group 7 Lodgepole pine seedling cohort dominance with minor fir and spruce components. Ross sedge is the main understory component. This group has members at 8900-9100 feet elevation.

Groups 8 and 9. Recent clearcuts and clearcuts from the 1970s and 1980s in the spruce-fir covertype. These have more fir seedlings and saplings than lodgepole pine. Spruce is a minor component. Both of these groups have very low per cent cover of *Vaccinium* and other understory species are mostly grasses or forbs including dandelion and thistle. These stands have an understory composition most characteristic of early seral stages or continued disturbance. All are above 9100 feet.

2. Successional dynamics and above ground structure

a. In lodgepole pine forests in the southern Medicine Bow Mountains there are similar cohorts of vascular plant species after 40-50 years of succession in clearcuts. This suggests that 40-50 years is approximately the time it takes a clearcut lodgepole stand to develop an understory of vascular plants similar to an older (100-150 years) uncut stand.Both logged and unlogged forests are

grazed by cattle so the biological diversity of these forests may not be comparable to forests that are both unlogged and not grazed by livestock. The infuence of livestock grazing and wildlife herbivory on vascular plant understory composition is unknown, but areas near roads in uncut stands had fewer understory forbs and grasses than areas farther from the roads (von Ahlefeldt, personal observation). It would be necessary to compare both uncut and regenerating forests to ungrazed reference areas to determine possible grazing effects on understory composition for both logged and unlogged sites.

b. There are other structural differences between logged and unlogged lodgepole forests with regard to downed wood, snags, and non-vascular plant species such as lichens and mosses.

c. Spruce-fir forests at higher elevations in the Medicine Bow Mountains (mostly in the northern portion of the range) recover from clearcutting more slowly than the lodgepole pine forests. Understory vascular plant composition after half a century was not as comparable to uncut forests as for lodgepole pine regenerating for a similar period of time. Even greater differences existed in structural components (canopy height, numbers of layers in the understory, amount and size of downed woody material, presence of decaying wood, mosses and lichens) between the spruce-fir forests cut 40-50 years ago and uncut forests. Lodgepole pine uncut forests are 150-200 years old but uncut spruce-fir forests are generally more than 200 years old

d. Unlogged forests had differences in moss, fungal and liche components (See Appendix 7), suggesting differences i decomposition processes, macroinvertebrate populations and possibly small mammal populations.

e. Succession proceeds at different rates at different sites. This accounts for the mixture of stand ages since cutting in some of the groups. The successional rates and trajectories are probably also influenced by post-harvest treatment and livestock and wildlife herbivory.

f. Subalpine fir seedlings are a major component of tree composition in all stands, both clearcut and uncut. At low elevations, there is little question that lodgepole pine is regenerating successfully and it is likely that in 80-100 years the new forest will be similar to the forests left from the tie-hacking and fires of the 1860-1900 period. For high elevation forests (above 9200 feet) and in particular for forests above 9800 feet, Engelmann spruce will not be a significant component for at least another century based on the species composition behavior of 40-50 year old cut stands measured in this study. Billings (1969)

estimated that it would take about 600 -700 years for old-growth spruce-fir forests to develop at high elevations in the Medicine Bow Mountains after a stand-destroying disturbance. Additional study is needed to determine 1. the length of time needed to grow merchantable spruce 2. the length of time needed to replace the major components of old spruce-fir forest.

3. **Mycorrhizal behavior and soil properties**

a. The results suggest that it takes alt least 20 years for the mycorrhizal recolonization of roots to reach levels comparable to uncut forests. Mycorrhizal propagules likely remain in soil after a clearcut bue become apparant only after plant hosts are available.

b. Mycorrhizae do not appear to be important components in the wetter spruce-fir sites. Although these are upland sites, they are characterized by springs and patches of facultative riparian species. These clearcut high-elevation spruce-fir sites have a heavy cover of grass and sedge which provides summer pasture for sheep. Spruce grows very slowly at these sites. Cut defective trees not removed from the site are present as large boles which are weathering but not decomposing very well. This is a similar condition to the burns near Towner Lake and the southern part of Libby Flats which occurred about 200 years ago, and which still have many large tree boles which have not decomposed (Billings, 1969).

MANAGEMENT IMPLICATIONS

1. On a landscape scale, the spruce component is decreasing in the short term (<100 years) timeframe, and the fir component is increasing due to differential regeneration. This can be infuenced some by thinning practices, but is limited by spruce seedling establishment and survival.

2. Thinning at 20-30 years has an important influence on the mix of lodgepole pine and subalpinefir, or spruce and subalpine fir. Goals for forest management for biological diversity as well as wood volume production need to be developed to accommodate a full array of biological diversity values.

3. The kinds of communities which we see now from cuts in the 1950s and 1960s may not be produced 40-50 years from now from clear cuts done in the 1980s and 1990s. Clearcut cutting post-treatment policies and snag retention policies have varied from 1950-1992. In the 1950s and 1960s, submature live spruce and fir trees were left in clearcuts. These trees modified microclimates

and provided vertical structure and a proximal seed source. The effects of rollerchopping on successional attributes other than tree regeneration are not known. It appears that the strong shrub component in Group 1 may be present because shrub species were not totally removed by post-treatment practices. Rollerchopping destroys shrubs and submature trees. It is possible that the diversity produced 50 years hence in stands rollerchopped will be comparable to what is present in stands cut in 1950-1960.

5. In 40 - 50 years, lodgepole pine stands at lower elevations have developed an understory composition similar to uncut stands, but less diversity in the overstory structure (less height, fewer canopy caps, less variety in structure due to disease and damage). In a few stands, mosses and lichens are beginning to appear, but there are major differences between these stands and uncut stands in the lichen components and the presence of large, down, decaying material. Succession to conditions similar to the mature forest is probably in the vicinity of 75-100 years.

6. In 40-50 years, spruce-fir stands at higher elevations have understory components only partly similar to uncut stands, and substantial differences exist between the overstories and other structural components of these regenerating stands and uncut areas. These differences include amount of shade, presence of arboral lichens, soil lichens and decaying-wood lichens, humidity, wind exposure, and decay. Although woody material was left after clearcutting, it weathers more than it decays, because conditions of temperature and moisture are not conducive to the presence of decay fungi. Mosses may be present, especially on north aspects, but fungi and lichens are sparse to absent. Saplings and poles are shorter (<15 feet high) and not very dense. Succession to conditions similar to the uncut forest will likely be in the order of 200-300 years.

7. The effect of rollerchopping on mycorrhizal recovery is not known. It is not known how understory shrub recovery for mycorrhizal species (silver buffaloberry, *Vaccinium or Ceanothus sp.* (buckbrush)) are affected by rollerchopping.

BIOLOGICAL DIVERSITY CONSIDERATIONS

Biological diversity at the stand level can be described using species composition, and stand structure. Processes and ecoystem functions resulting from and contributing to biological diversity is mostly inferred from compostion and structure. At the landscape level, the overall species composition, age structure, patch size, connectivity and processes and function within patches can be used

to describe biological diversity. This is an important part of cumulative effects analysis and is discussed elsewhere in the Medicine Bow National Forest Biological Diversity Reort.

This study of biological diversity of clearcuts created in the last half century is a beginning to yield information. Some of the biological diversity considerations which are suggested by this study are:

1. At the stand level, establishment and persistence of understory shrubs beneath lodgepole pine stands emerged as an important consideration for biological diversity. Some of these shrubs have nitrogen-fixing organisms associated with their roots and are thus an important part of the nutrient budget in these forests.

2. The attenuation of decomposition processes due to the absence of fungi in patches of forest less than 50 years old has implications for biological diversity of macroinvertebrates. This is true also for the virtual absence of lichens and mosses from these systems.

3. Invasion by noxious weeds is not a major problem in clearcuts in the Medicine Bow mountains. Mycorrhizal levels apparantly recover slowly, possibly limited by plant host availability.

4. Clearcuts, and the successional processes associated with them, do increase species richness and diversify some aspects of compostion, structure, process and function of biological systems, but at the expense of other aspects.

5. Aspects of biological diversity associated with old forests (>150 years for lodgepole pine and >200 years for spruce-fir) need further evaluation, especially at the landscape scale. Lichens, fungi and mosses, which develop slowly and only in the shady, relatively humid and non-windy environments provided by tall canopied, often multilayered forests, are an important part of the biological diversity of these forest systems. These non-vascular species provide food for animals from small mammals to moose, deer and elk and are essential habitat for a host of macroinvertebrates. Forests which have been clearcut logged lack lichens, mosses and most fungi.

Leavell (1993) hypothesized that lodgepole pine in the Blue Mountains of Oregon may associate with mycorrizae not utilized by other conifers or may not be dependent on mycorrhizae at all to recolonize disturbed (clearcut and/or burned) sites. In the Blue Mountains of Oregon, highly productive grand fir and Douglas-fir forests regenerate to lodgepole pine after clearcutting. Leavell

argues that the loss of mycorrhizae after clearcutting harvest essentially lowers site productivity. Thus clearcut harvest of grand fir and Douglasfir sites, especially if followed by broadcast burning impacts productive sites and lowers their productivity at least for a protracted period of time until other conifers requiring mycorrhizae can colonize the disturbed area.

As a rule, sites in the southern Medicine Bow Mountains have severe limitations due to cold and dryness and lodgepole pine is particularly well suited to dominate the systems. The disturbances from fire in the last century have contributed to the widespread occurrence of lodgepole pine throughout the souther Medicine Bow Mountains. Howeer, the presence of patches of old spruce-fir missed by fires or clearcut harvest throughout the area attest to the potential of the Medicine Bow Mountains to support spruce-fir forest. Indeed, most mature lodgepole pine stands have a vigorous understory consisting mainly of fir saplings, poles and submatue trees.

It is possible that the entire area is in various early to mid seral stages to spruce-fir forest, but recurring disturbance from clearcutting will retain the area in lodgepole pine. At higher elevations in the Northern Medicine Bow Mountains, many spruce-fir clearcuts are regenerating to lodgepole pine. The data from this study indicate that conifer ectomycorrhizal levels may be a contributing factor. Other sites are regenerating to spruce and fir, especially at high elevations where lodgepole pine will not establish and survive. Regeneration of any kind has been a problem in the past in some of these clearcuts. Microclimate is certainly also a contributing factor, but loss of mycorrhizae following clearcutting may also be important. The data from this study show a significant loss of conifer ectomycorrhizae follwing clearcutting. On wetter sites at high elevetations, mycorrhizae may not be as important for conifer establishment, and other factors wuch as competition from grasses and forbs may inhibit tree reestablishment.

In summary, the results indicate that clearcutting of lodgepole pine in the southern Medicine Bow Mountains, as practiced in the 1950-1960s causes changes which appear to recover to conditions similar to the uncut forest in about a century. In contrast, clearcutting of spruce-fir, especially at higher elevations, effectively removes forest and associated ecosystem composition, structure, processes and functions for a much longer time, possibly 200 or more years.

Field work was done by Patrick McLaughlin and Sally Tinker under the supervision of Judy von Ahlefeldt, Forest Ecologist. It was funded by funds targeted for Ecosystem Management

LITERATURE CITED

Billings, W.D. 1969. Vegetational pattern near alpine timberline as affected by fire-snowdrift interactions. Vegetatio 19:192-207

Christiansen, N.L., Agee, J.K., Brossard, P.F., Hughes, J., Knight, D.H., Minshall, G.W., Peck, J.N., Pyne, S.J., Swanson, F.J., Thomas, J.W., Wells, S., Williams, S.E., Wright, H.A. 1989. Interpreting the Yellowstone Fires of 1988. Bioscience 39(10):678-685.

Grand, L.F. and A.E. Harvey. 1982. Quantitative measurement of Ectomycorrhizae on Plant Roots. Chapter 14 IN: Schenck, N.C. (ed.) **Methods of Principles of Mycorrhizal Research.** An. Phytopath. Soc. St Paul, Minn. pages 157-164

Marston, R.A. and D.T. Clarendon. 1988. *Land Systems Inventory of the Medicine Bow National Forest, Wyoming* USDA Medicine Bow National Forest Laramie, WY

Leavell, D.M. 1993. Draft report on clearcutting, fire and succession in the Blue Mountains, Umatilla, Wallowa-Whitman and Malheur National Forests.

Zhao, Z. 1995. personal communication.

Zhao, Z., von Ahlefeldt, J. and S.E. Williams. 1995. Mycorrhizae of the clear cut sites of the Medicine Bow National Forest in southeastern Wyoming. In preparation.

TABLE AP16.1 Common Landtypes used for clearcut site selection in the Medicine Bow and Sierra Madre Mountains (from Marston, 1988)

IDNumber	Vegetation	Substrate	Morphology
12	Mixed Forest -	Crystalline -	Low Mountains
13	Coniferous -	Crystalline-	Mountains
4	Coniferous -	Crystalline -	High Hills
7	Coniferous -	Quaternary-mantled -	Low Hills
9	Coniferous -	Quaternary-mantled -	Hills (deep soils)
5	Coniferous -	Sedimentary -	High Hills
15	Mixed Forest -	Sedimentary -	Mountains
17	Mixed Forest -	Sedimentary -	Hills
18	Mixed Forest -	Quaternary-mantled -	Low Mountains
20	Coniferous -	Crystalline -	Canyons

TABLE AP16.2 Macrofungi genera from clearcut and uncut sites

Genus	Stand	Category	Cover Type
Amanita	1980s		lodgepole pine
Cortinarius	1950s		lodgepole pine
Clitocybe	1960s	uncut	spruce-fir
Entoloma	1960s		spruce-fir
Hebeloma	1970s		spruce-fir
Inocybe		uncut	spruce-fir
Laccaria	1980s		lodgepole pine
Lycoperdon		uncut	spruce-fir
Rhizopogon	1950s		lodgepole pine
Russula		uncut	spruce-fir
Tricholoma	1950s 1990s	uncut	lodgepole pine spruce-fir

TABLE AP16.3 **Species list for ordination groups. If only the genus is known, the acronym is in caps.** * indicates nitrogen-fixer ** possible nitrogen fixer

ACRO	Common name		Genus	species
			TREES	
Abla	subalpine fir		Abies	lasiocarpa
Pien	Engelmann's spruce		Picea	engelmannii
Pipo	ponderosa pine		Pinus	contorta
Pifl2	limber pine		Pinus	flexilis
Potr5	quaking aspen		Populus	tremuloides
Psme	douglasfir		Pseudostuga	menzesii
			SHRUBS	
Acgl	Rocky Mountain maple		Acer	glabrum
Aruv	kinnikinnik		Arctostaphylos	uva-ursi
Ceve	snowbrush ceanothus	*	Ceanothus	velutinus
Chum	pipsissewa		Chimaphila	umbellata
CHRY	rabbitbrush		Chrysothamnus	spp.
Juco6	common juniper		Juniperus	communis
Loin5	twinberry honeysuckle		Lonicera	involucrata
Mare11	Oregongrape		Mahonia	repens
Pyas	liverleaf wintergreen		Pyrola	asarifolia
Pych	greenflowered wintergreen		Pyrola	chlorantha
PYRO	wintergreen		Pyrola	spp.
Rice	wax currant		Ribes	cereum
Riin2	whitestem gooseberry		Ribes	inerme
Rila	prickly currant		Ribes	lacustre
Rimo2	gooseberry currant		Ribes	montigeum
RIBES	currant		Ribes	spp.
Rowo	Wood's rose	**	Rosa	woodsi
RUBUS	raspberry		Rubus	spp.
SALIX	willow		Salix	spp.
Shca	russett buffaloberry	*	Shepherdia	canadensis
SORBUS	green mountain ash		Sorbus	spp.
Vasc	grouse whortleberry		Vaccinium	scoparium
			FORBS	
Acmi2	common yarrow		Achillea	millefolium
AGOS	agoseris		Agoseris	spp.
Albr2	shortstyle onion		Allium	brevistylum
ANAP	pearlyeverlasting		Anaphalis	spp.
ANDR	rock jasmine		Androsace	spp.
Anpa4	small-leaf pusseytoes		Antennaria	parvifolia
ANTE	pusseytoes		Antennaria	spp.
ARAB	rockcress		Arabis	spp.
Arfe3	Fendler's sandwort		Arenaria	fendleri
Arco9	heartleaf arnica		Arnica	cordifolia
Arla8	broadleaf arnica		Arnica	latifolia

TABLE AP16.3 continued

ACRO	Common Name		Genus	species
ARNI	arnica		Arnica	spp.
Asfo	alpine leafybract aster		Aster	foliaceous
ASTER	aster		Aster	spp.
Asal7	alpine milkvetch	*	Astragalus	alpinus
ASTR	milkvetch	*	Astragalus	spp.
Cale	white marshmarigold		Caltha	leptosepala
Cabu	fairyslipper orchid		Calypso	bulbosa
Caro2	bluebell bellfower		Campanula	rotundifolia
CAST	Indian paintbrush		Castilleja	spp.
Casu12	sulfur paintbrush		Castilleja	sulfurea
Cear4	field chickweed		Cerastium	arvense
CHEN	goosefoot		Chenopodium	spp.
CICU	water hemlock		Cicuta	spp.
Cical1	prairie thistle		Cirsium	canescens
CIRS	thistle		Cirsium	spp.
CLAY	springbeauty		Claytonia	spp.
Copa3	small flower blueyed Mary		Collinsia	parviflora
COLL	narrowleaf mountain trumpet		Collomia	spp.
Deoc	duncecap larkspur		Delphinium	occidentale
DRAB	whitlowgrass		Draba	spp.
Drpa2	American dragonhead		Dracocepalum	parviflora
Epan2	fireweed		Epilobium	angustifoli
EPIL	willowherb		Epilobium	spp.
Erco4	fernleaf fleabane		Erigeron	compositus
ERIG	fleabane		Erigeron	spp.
ERIO	buckwheat		Eriogonum	spp.
Ergr9	dogtooth lily		Erythronium	grandiflorum
Frvi	Virginia strawberry		Frageria	virginiana
Gabo2	northern bedstraw		Galium	boreale
Gara	blackfoot groundsmoke		Gayophytum	racemosum
Geam3	autumn dwarf gentian		Gentianella	amarella
Geca3	pineywoods geranium		Geranium	caespitosum
Geri	Richardson's geranium		Geranium	richardsonii
Hatr	whiskbroom parsley		Harbouria	trachypleura
HELI	sunflower		Helianthus	spp.
Hial2	white hawkweed		Hieracium	abiflorum
Higr	slender hawkweed		Hieracium	gracile
LATH	peavine		Lathyrus	spp.
Lifi	fernleaf licoriceroot		Ligusticum	filicinum
LIGU	licoriceroot		Ligusticum	spp.
Lise	northern linanthus		Linanthus	septentrionalis
Livu2	butter and eggs		Linaria	vulgaris
LOMA	biscuitroot		Lomatium	spp.

TABLE AP16.3 continued

ACRO	Common Name		Genus	species
Luar3	silvery lupine	*	Lupinus	argenteus
MERT	bluebells		Mertensia	spp.
Mile2	purple monkeyflower		Mimulus	lewisii
Osde	bluntseed sweetroot		Osmorhiza	depauperata
OSMO	sweetroot		Osmorhiza	spp.
PARO	nailwort		Paronychia	spp.
Pebr	bracted towering lousewort		Pedicularis	bracteosa
Pera	sickletop lousewort		Pedicularis	racemosa
PEDI	lousewort		Pedicularis	spp.
PENS	penstemon		Penstemon	spp.
Pevi3	Front Range beardtongue		Penstemon	virens
Pewh	Whipple's penstemon		Penstemon	whippleanus
PHAC	scorpionweed		Phacelia	spp.
PHLO	phlox		Phlox	spp.
PLAN	bog orchid		Platanthera	spp.
Pobi6	American bistort		Polygonum	bistoides
Podo4	Douglas' knotweed		Polygonum	douglasii
POLY	knotweed		Polygonum	spp.
Pofi3	bigflower cinquefoil		Potentilla	fissa
POTE	cinquefoil		Potentilla	spp.
Poru3	Rocky Mountain cinquefoil		Potentilla	rubricaulis
Ptan2	woodland pinedrops		Pterospora	andromeda
Pyla	lanceleaf goldenweed		Pyrrocoma	lanceolata
RANU	buttercup		Ranunculus	spp.
RUME	dock		Rumex	spp.
Sarh2	diamondleaf saxifrage		Saxifraga	rhomboidea
Saxi	saxifrage		Saxifrage	spp.
Sela	spearleaf stonecrop		Sedum	lanceolatum
SEDE	stonecrop		Sedum	spp.
Secr	thickleaf groundsel		Senecio	crassulus
Sedi4	variflower groundsel		Senecio	dimorphophyllus
Seer2	desert groundsel		Senecio	eremophilus
Sese2	butterweed groundsel		Senecio	serra
SENE	groundsel		Senecio	spp.
Setr	arrowleaf groundsel		Senecio	triangularis
Sesw2	hoary groundsel		Senecio	werneriaefolius
SOLI	goldenrod		Solidago	spp.
SPER	sandspurry		Spergularia	spp.
Stam2	claspleaf twistedstalk		Streptopus	amplexifolius
TARA	dandelion		Taraxacum	spp.
Thfe	Fendler's meadowrue		Thalictrum	fendleri
TRAG	salsify		Tragopogon	spp.
TRIF	clover	*	Trifolium	spp.
Vete4	Colorado false-hellebore		Veratrum	tenuipetalum
VERA	false-hellebore		Veratrum	spp.
VERO	speedwell		Veronica	spp.
Viad	hookedspur violet		Viola	adunca
VIOL	violet		Viola	spp.
Ziel2	deathcamas		Zygadenus	elegans

TABLE AP16.3 concluded

ACRO	Common Name	Genus	species
		GRAMINOIDS	
Agex	spike bentgrass	Agrostis	exarata
Agsc5	rough bentgrass	Agrostis	scabra
AGRO	bentgrass	Agrostis	spp.
Agva	mountain bentgrass	Agrostis	variabilus
Bran	nodding brome	Bromus	anomalus
Brca5	rattlesnake brome	Bromus	carinatus
Brci2	fringed brome	Bromus	ciliatus
BROM	brome	Bromus	spp.
Caca4	bluejoint reedgrass	Calamagrostis	canadensis
Cage2	elk sedge	Carex	geyeri
Cami7	smallwing sedge	Carex	microptera
Caro6	Ross' sedge	Carex	rossii
CAREX	sedge	Carex	spp.
Dagl	orchardgrass	Dactylis	glomerata
DESC	hairgrass	Deschampia	spp.
Elca4	Canada wildrye	Elymus	canadensis
Elel5	bottlebrush squirreltail	Elymus	elymoides
Feid	Idaho fescue	Festuca	idahoensis
FESC	fescue	Festuca	spp.
BARL	barley	Hordeum	spp.
Juba	Baltic sedge	Juncus	balticus
Koma	prairie Junegrass	Koeleria	macranth
Lupa4	smallfowered woodrush	Luzula	parviflo
Oras	roughleaf ricegrass	Oryzopsis	asperifolia
Orex	little ricegrass	Oryzopsis	exigua
Phal2	alpine timothy	Phleum	alpinum
PHLE	timothy	Phleum	spp.
Poco	Canada bluegrass	Poa	compressa
Pofe	muttongrass	Poa	fendleriana
POA	bluegrass	Poa	spp.
Pone3	Nevada bluegrass	Poa	nevadensis
Pore	nodding bluegrass	Poa	reflexa
Pssps	bluebunch wheatgrass	Pseudoroegnaria	spicata
Stpi2	pine needlegrass	Stipa	pinetorum
Trsp2	spike trisetum	Trisetum	spicatum

TABLE AP 16.4 Shrub Presence in Ordination Groups

Shrub Species	Ordination Group										
	11	10	5	9	8	6	7	4	3	1	2
grouse whortleberry	x	x	x	x	x	x	x	x	x	x	
Wood's rose	x			x	x	x	x	x	x	x	x
common raspberry		x		x		x			x	x	x
gooseberry currant			x	x	x	x			x	x	
common juniper			x	x	x	x	x		x	x	x
Oregongrape				x	x	x	x		x	x	x
twinberry honeysuckle			x	x	x		x	x	x	x	x
green mountainash			x	x		x					
willow spp.				x	x	x	x	x	x		
prickly currant				x					x		
rabbitbrush spp.					x				x		
wax currant					x					x	x
russett buffaloberry						x	x	x	x	x	x
kinnikinnik						x	x	x		x	x
snowbrush ceanothus									x		x
whitestem gooseberry										x	
currant spp.											x

TABLE AP16.5 Major species in each ordination group (See Table 3 for acronyms) Column 1 (Group) gives the ordination group number, the year of origin and the number of stands in the group (..) . Species with 1% cover are listed by acronym only. Genus only names are in caps.

Group	Trees	Shrubs	Forbs	Graminoids
1	Pico (25-40%)	15 species	35 species	10 species
Pico	Abla (1-30%)	Juco (0-15%)	Arco (0-10%)	Cage
controls(2)	Pien (1-10%)	Mare (0-10%)	Luar (0-5%)	Caro
1950 (5)	Potr (0-5%)	Vasc (0-10%)	Epan2	
1981 (1)		Shca (0-5%)	Frvi	
		Aruv (0-5%)	Anpa	
		Rowo (0-5%	Pofi	
		Loin	Taof	
2	Pico (x-45%)	14 species	31 species	12 species
1960 (2)	Alba (x)	Vasc (1-5%)	Luar (0-5%)	Cage (x-1%)
1970 (1)	Pien (x)	Juco (x-1%)	Anpa	Caro (x-1%)
1990 (1)	Potr (0-x)	Rowo (0-1%)	Arco	POA
		Shca	CIRSIUM	
		Mare	Epan2	
			Frvi	
			Hial	
			Acmi	
			Taof	
3	Pico (1-30%)	9 species	29 species	11 species
1980 (2)	Pifl (0-present)	Aruv (0-5%)	Luar (1-10%)	Caro (1-5%
1990 (1)	Potr (0-45%)	Rowo (1-5%)	Epan2(0-5%)	Cage (0-1%)
		Mare	Arco (x-1%)	Feid (0-5%)
		Juco	CIRSIUM	POA (0-5%)
		Shca	Arabis	Koma
		Loin	Hial	
		Rubus	Anpa	
			Pewh	
			TARAXACUM	

TABLE AP16.5 continued

Group	Trees	Shrubs	Forbs	Graminoids
4	Pico (1-20%)	9 shrubs	31 forbs	12 grasses
1970 (2)	Abla (0-x%)	Juco	Acmi	Pone (0-15%)
1980 (1)	Pien (0-x%)	Mare	ANTENNARIA	Caro (x-5%)
1990 (2)	Potr (0-x%)	Rowo	Arco	Cage (x-1%)
		Sasc	CIRSIUM	Hoju (0-1%)
			Epan2	Sihy (0-1%)
			Frvi	
			HELIANTHUS	
			Sedi	
			SOLIDAGO	
			TARAXACUM	
5	Pien (5-25%)	6 species	20 species	6 grasses
SF Control	Abla (10-15%	Vasc (10-75%)	Aster (0-5%)	Agva (0-5%)
(5)	Pico (0-30%)	Rimo (0-x%)	Frvi (0-1%)	Elca (0-1%)
	Potr (0-5%)	PYROLA (0-1%)	Arco	Trsp
6	Pico (x-60%)	14 species	38 species	18 grasses
1955 (4)	Abla (x-25%)	Vasc (5-15%)	Anma (0-1%)	Cage
1960 (4)	Pien (x-15%)	Rimo (0-1%)	Anma	Caro
SF control	Potr (0-x%)	Juco (0-1%)	Arco (0-5%)	POA
(1)		Shca (0-1%)	ASTER(0-5%)	Trsp
		Pych	CIRSIUM	
		Rubus	Epan2 (0-1%)	
		Sasc	Frvi (0-5%)	
			HELIANTHUS	
			Luar (0-1%)	
			Pewh	
			SEDUM (0-5%)	
			Secr	
			TARAXACUM	

TABLE AP16.5 continued

Group	Trees	Shrubs	Forbs	Graminoids
7	Pico (x-50%)	9 shrubs	33 species	10 species
1960 (2)	Abla (x-2%)	Vasc	Acmi	Caro
1970 (2)	Pien (0-2%)	Aruv	Anpa	Cage
1980 (2)	Potr (0-1%)	Juco	Arco	POA
		Shca	Draba	Koma
		Rowo	Epan2	
		Loin	Frvi	
		Sasc	Hial	
			Luar	
			Taof	
8	Pico (5-65%)	9 species	44 species	17 species
1960 (1)	Abla (0-5%)	Vasc	Arco	Cage
1970 (1)	Pien (0-1%)	Rowo	CIRSIUM	Caro
1980 (1)	Potr (0-5%)	Mare	Epan2	Elca
1990 (1)			Frvi	POA
			Sedi	Trsp
			TARAXACUM	
9	Abla (0-10%)	11 shrubs	55 forbs	11 grasses
1960 (2)	Pico (0-5%)	Vacc	Anma	Caro
1970 (1)	Pien (0-1%)	RIBES	Anpa	Cage
1980 (2)	Potr (0-x%)	SORBUS	CIRSIUM	Trsp
1990 (4)		RUBUS	Epan2	
		ROSA	Pewh	
			Secr	
			Seer	
			TARAXACUM	

TABLE AP16.5 concluded

Group	Trees	Shrubs	Forbs	Graminoids
10	Pico (x-5%)	4 shrubs	25 forbs	11 grasses
1970 (2)	Abla (5%)	Vasc	AGOSERIS	Caro
	Pien (1-5%)	Rimo	Anma	Cage
			ARABIS	Trsp
			ASTER	
			Epan2	
			Hial	
11	Pien (x%)	2 shrubs	37 forbs	12 grasses
1970 (2)	Abla (0-x%)	Vasc	Anpa	Caro
	Pico (0-x%)	Rowo	ARABIS	POA
			SENECIO	PHLEUM
			TARAXACUM	

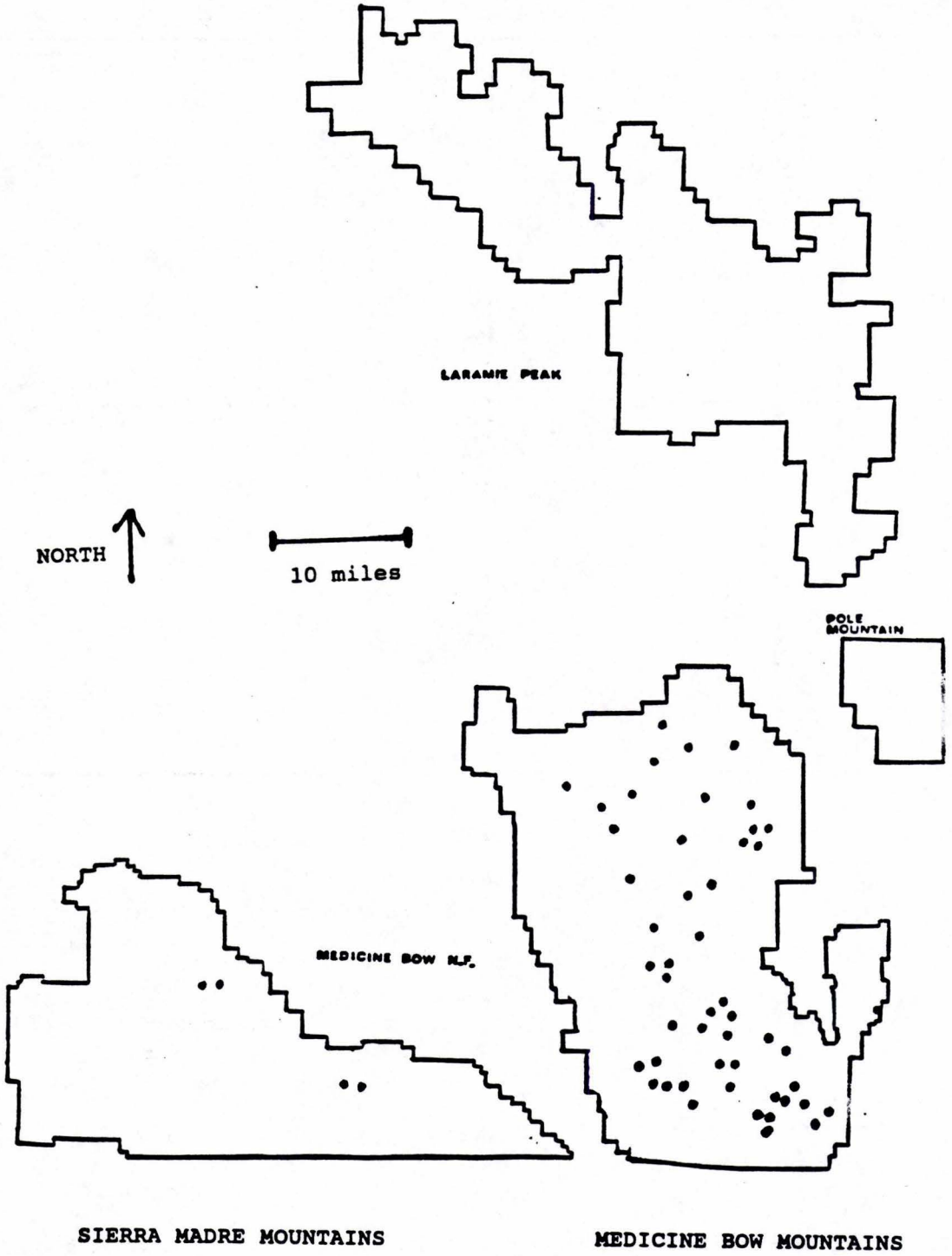


FIGURE AP16.1 Distribution of stands for the Clearcut Succession Study

ORDINATION GROUPS BASED ON UNDERSTORY VEGETATION

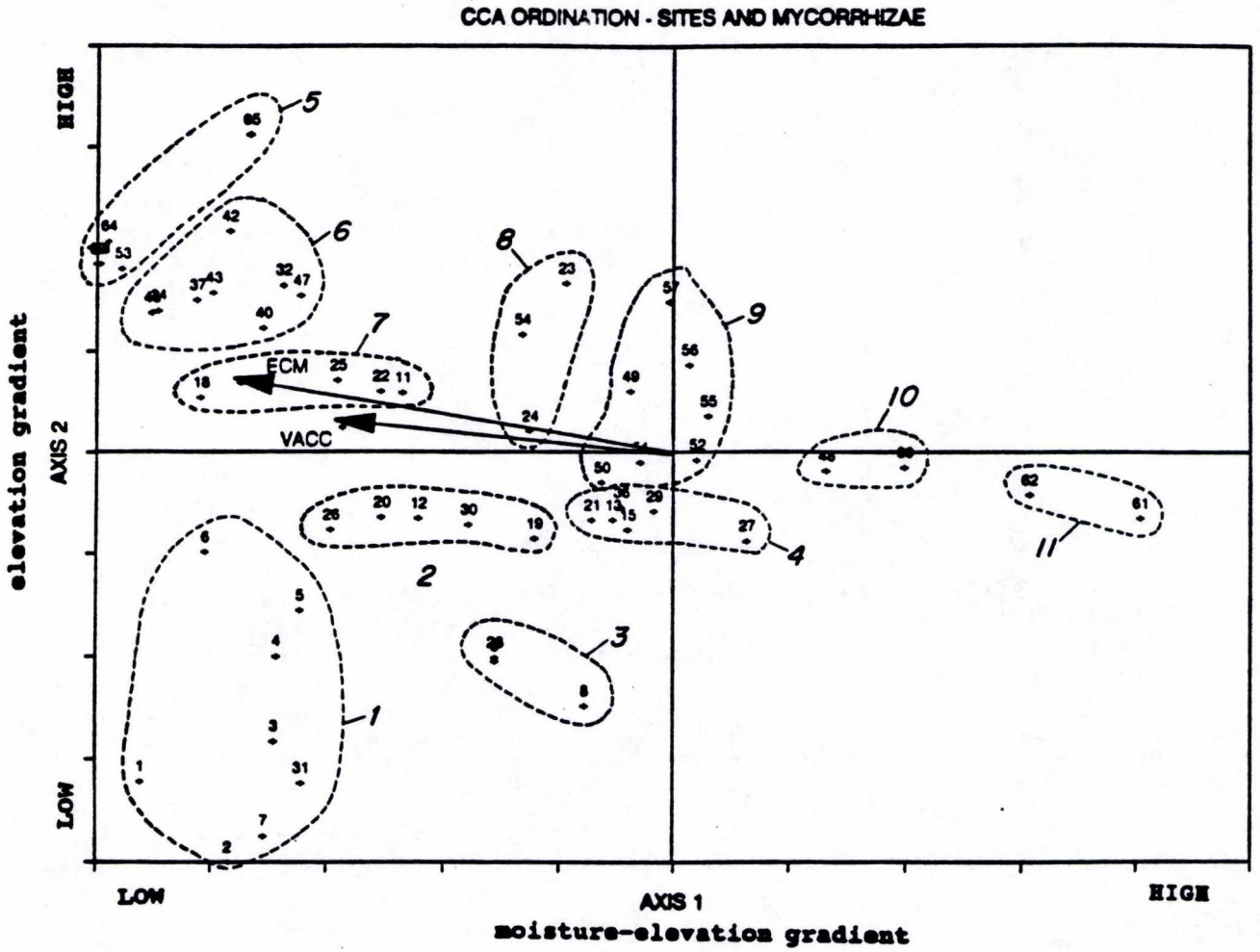


Figure AP16.2. Gradient Analysis of clearcut and uncut stands.

Groups 1-4 are lodgepole pine cover type

Group 1 is composed of uncut lodgepole pine forest and stands cut in the 1950s. Large shrubs occur in the understories.

Group 5 is uncut spruce-fir forest.

Groups 6-7 are mainly clearcut stands with a high per cent cover of *Vaccinium*.

Groups 8-9 are recently cut stands with many forbs and weeds.

Groups 10 -11 are high elevation stands which were cut in the early 1970s with riparian inclusions and understories of mainly grasses and forbs.

Axis 1 represents a moisture-elevation gradient from low to high.

Axis 2 is an elevation gradient from low to high.

The arrows represent the best statistical fit of the mycorrhizal infection levels for *Vaccinium* (VAC) and conifer (ECM). These mycorrhizal infection levels associate strongly with the gradient for dryness and weakly with the gradient for elevation.

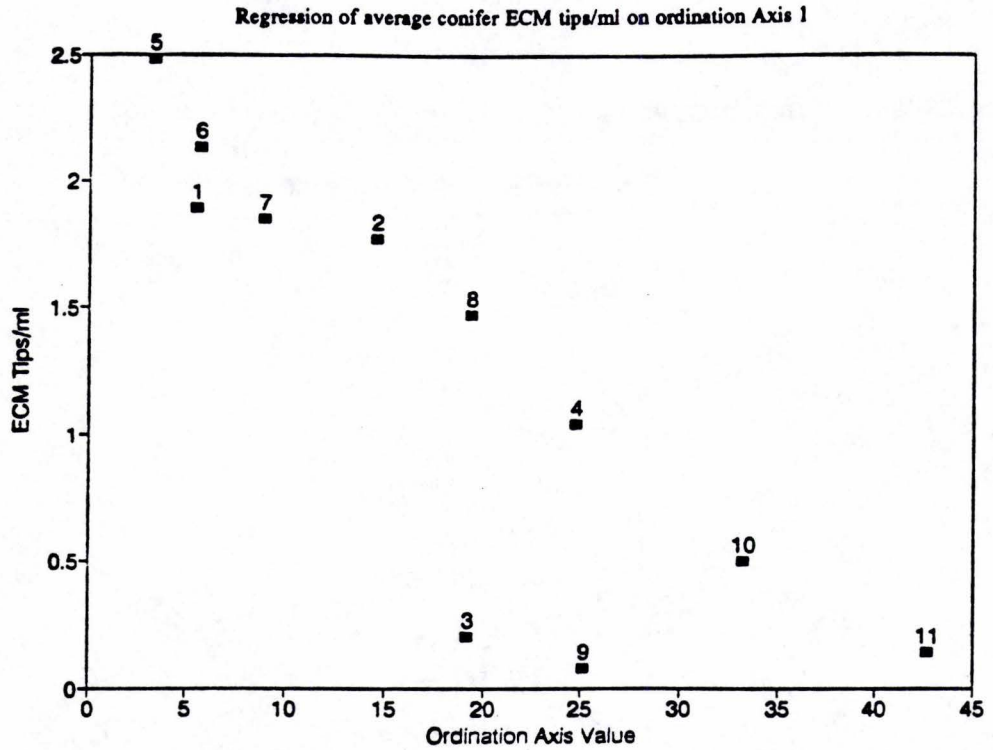


FIGURE AP16.3. Mean value of conifer ectomycorrhizal tips/ml (infection level) vs mean value (centroid) of each Ordination Group. Axis 1 is a low--->high moisture-elevation gradient and Axis 2 is a low to high infection level. R value = 0.85. See Photos M1 and M2

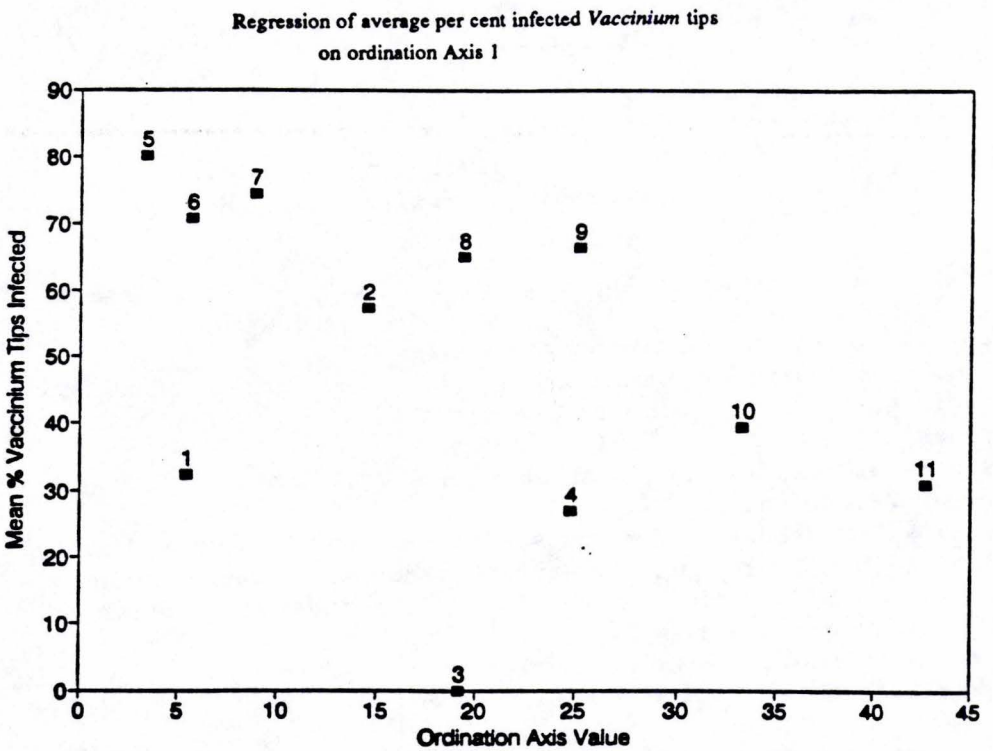
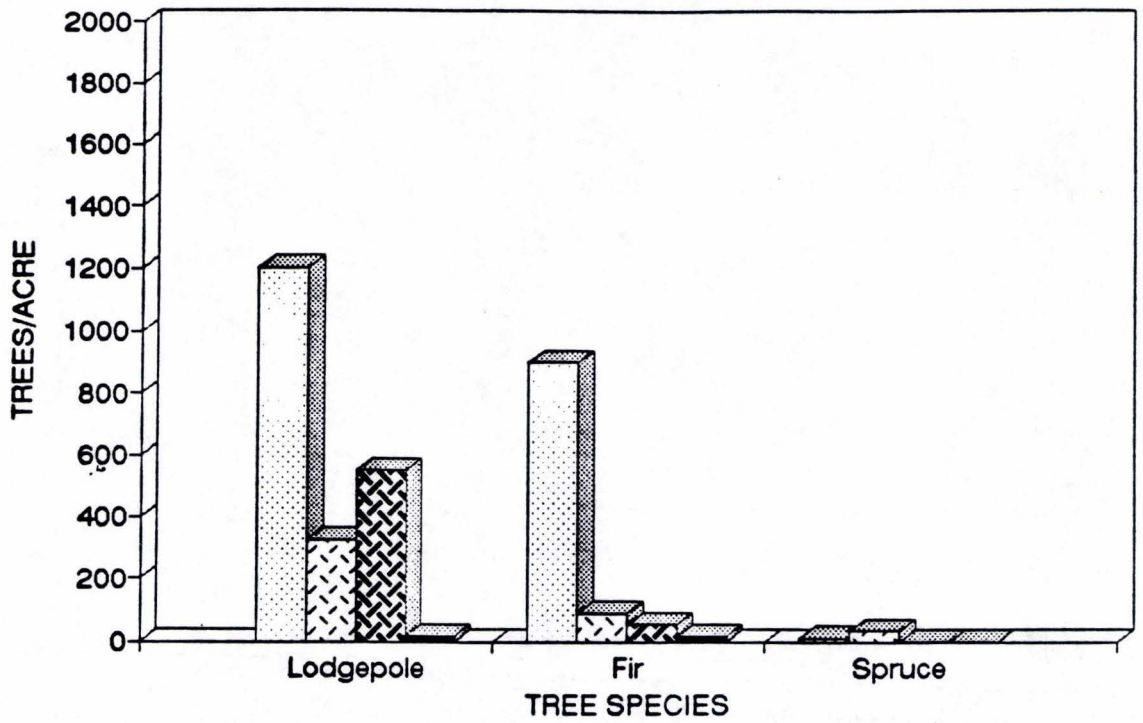


FIGURE AP16. 4. Mean value of percent infected Vaccinium tips. Axis 1 is a low--->high moisture-elevation gradient and Axis 2 is a low to high infection level gradient. R value = 0.46. See photos M3 and M4.



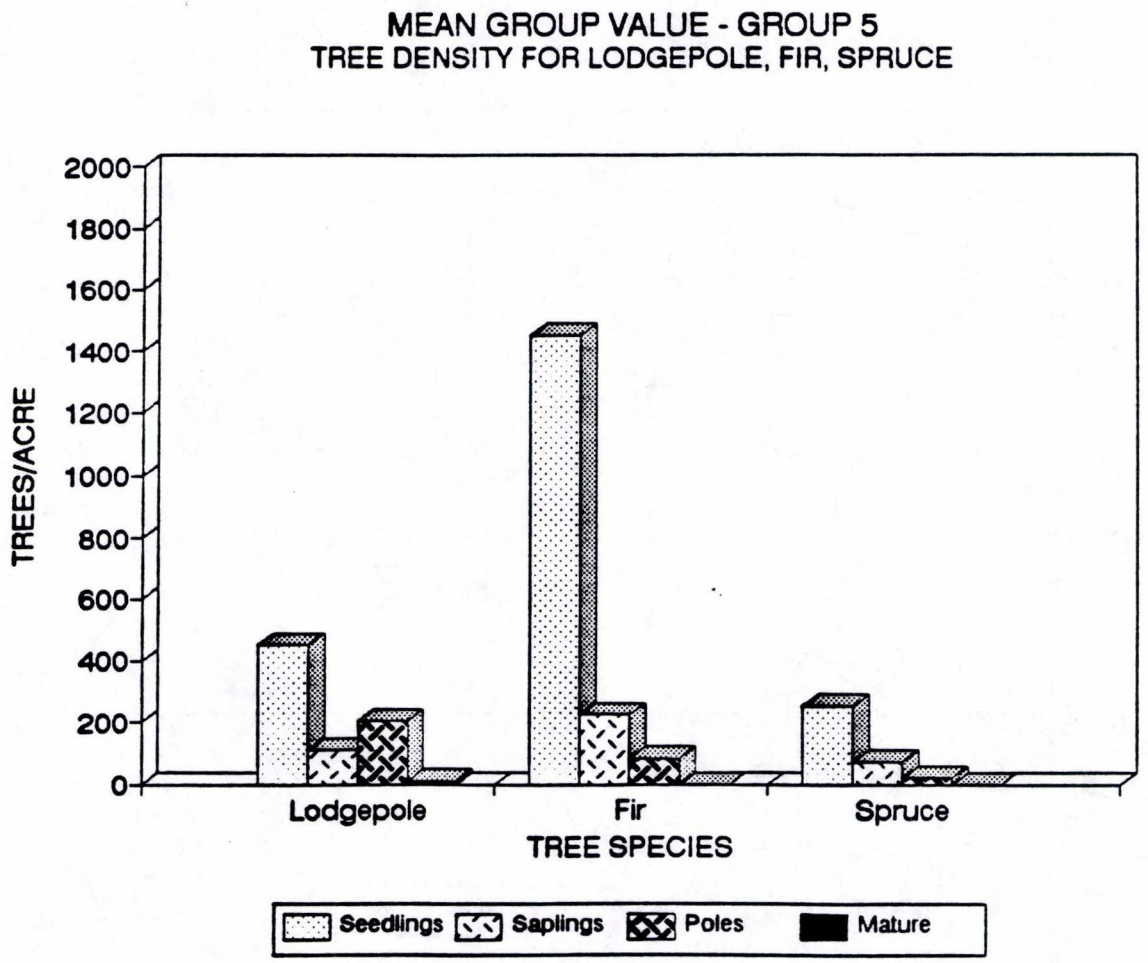
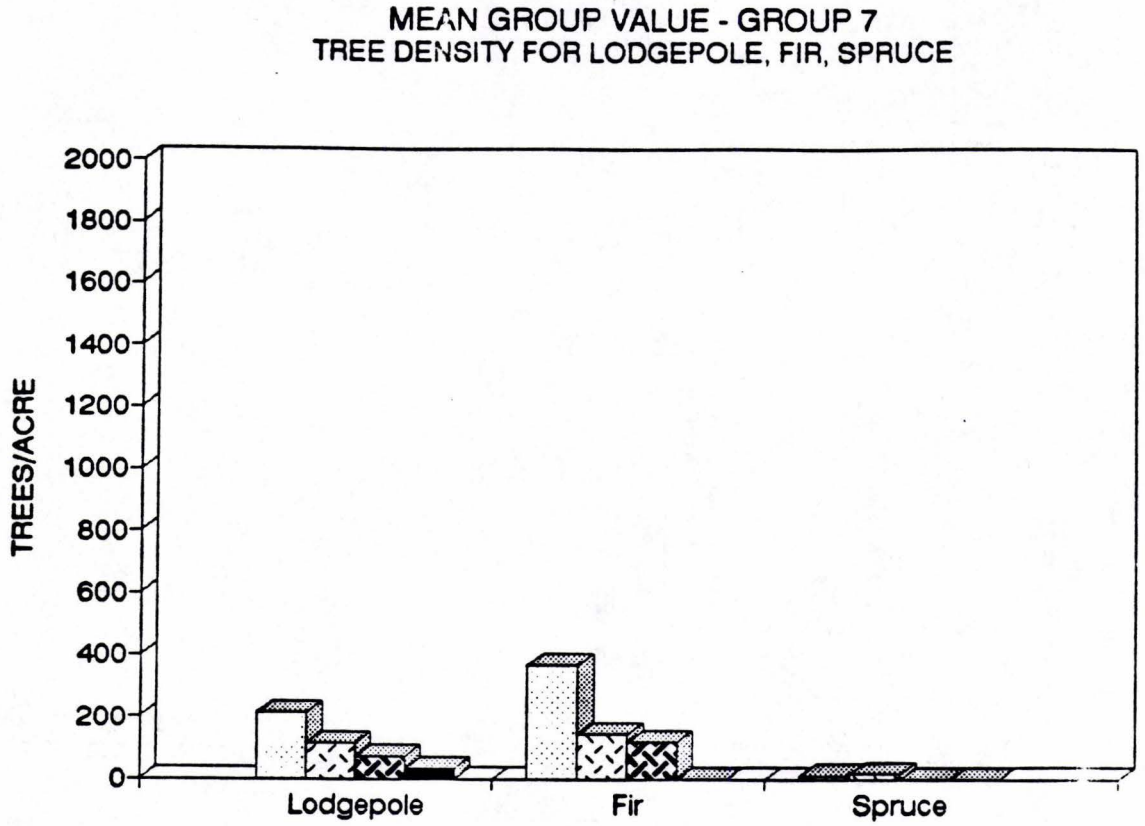


FIGURE AP16.5. Tree density for seedlings, saplings, poles and mature trees for three conifer species, Groups 1 and 5.



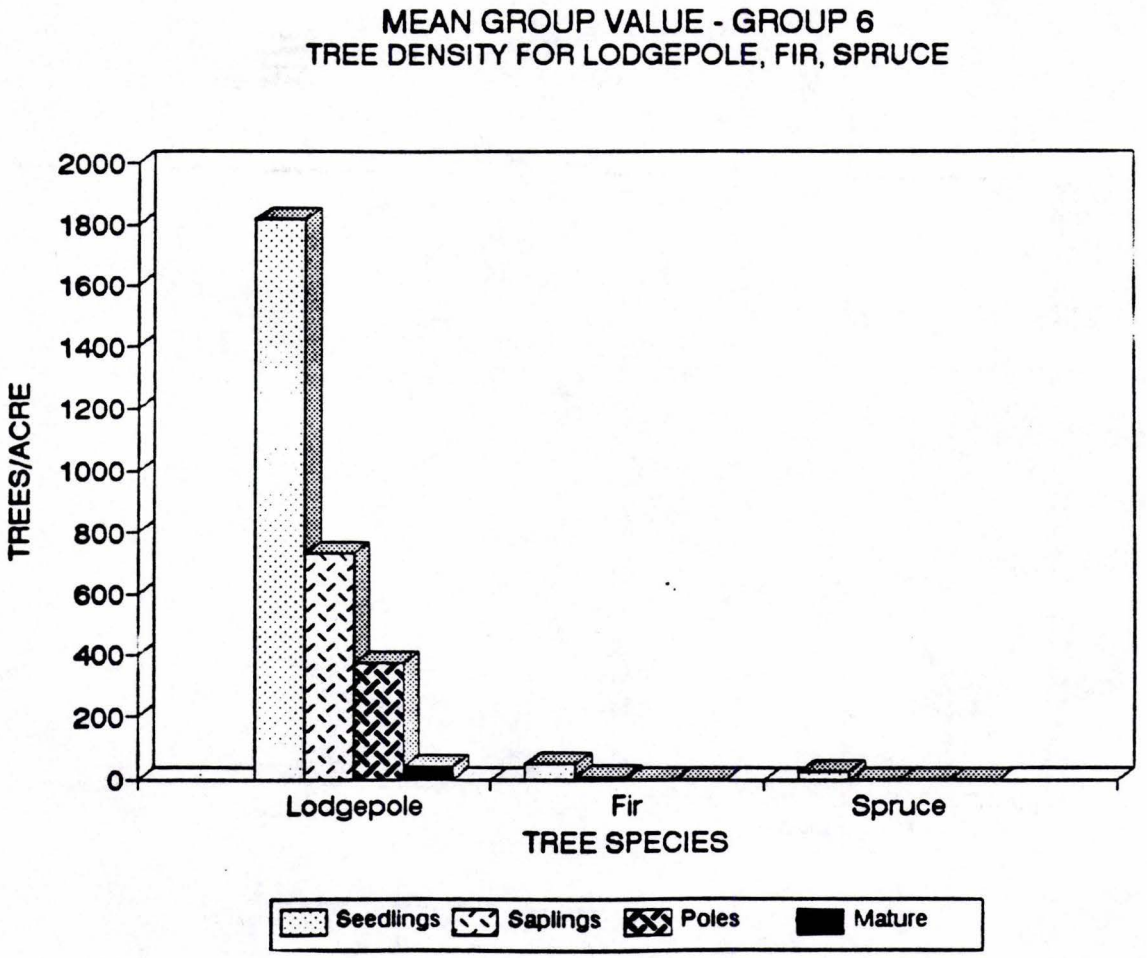
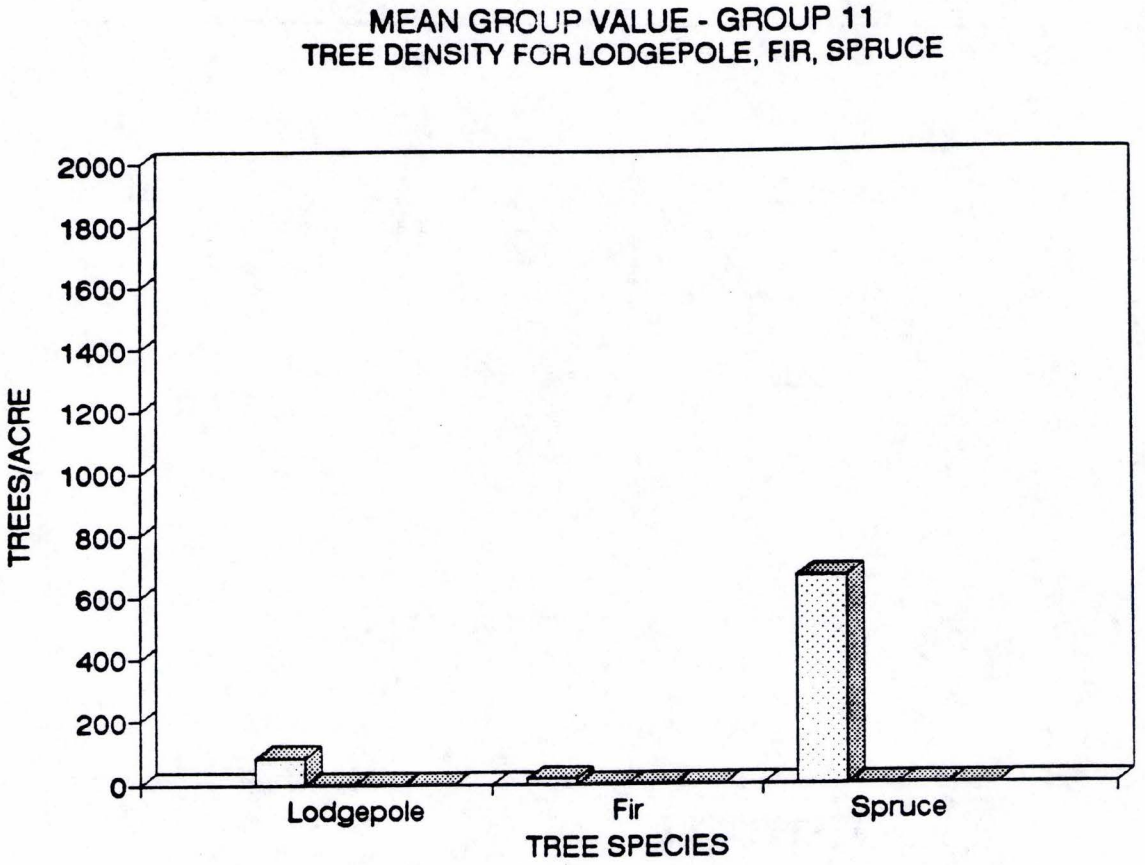


FIGURE AP16.6. Tree density for seedlings, saplings, poles and mature trees for three conifer species, Groups 6 and 7.



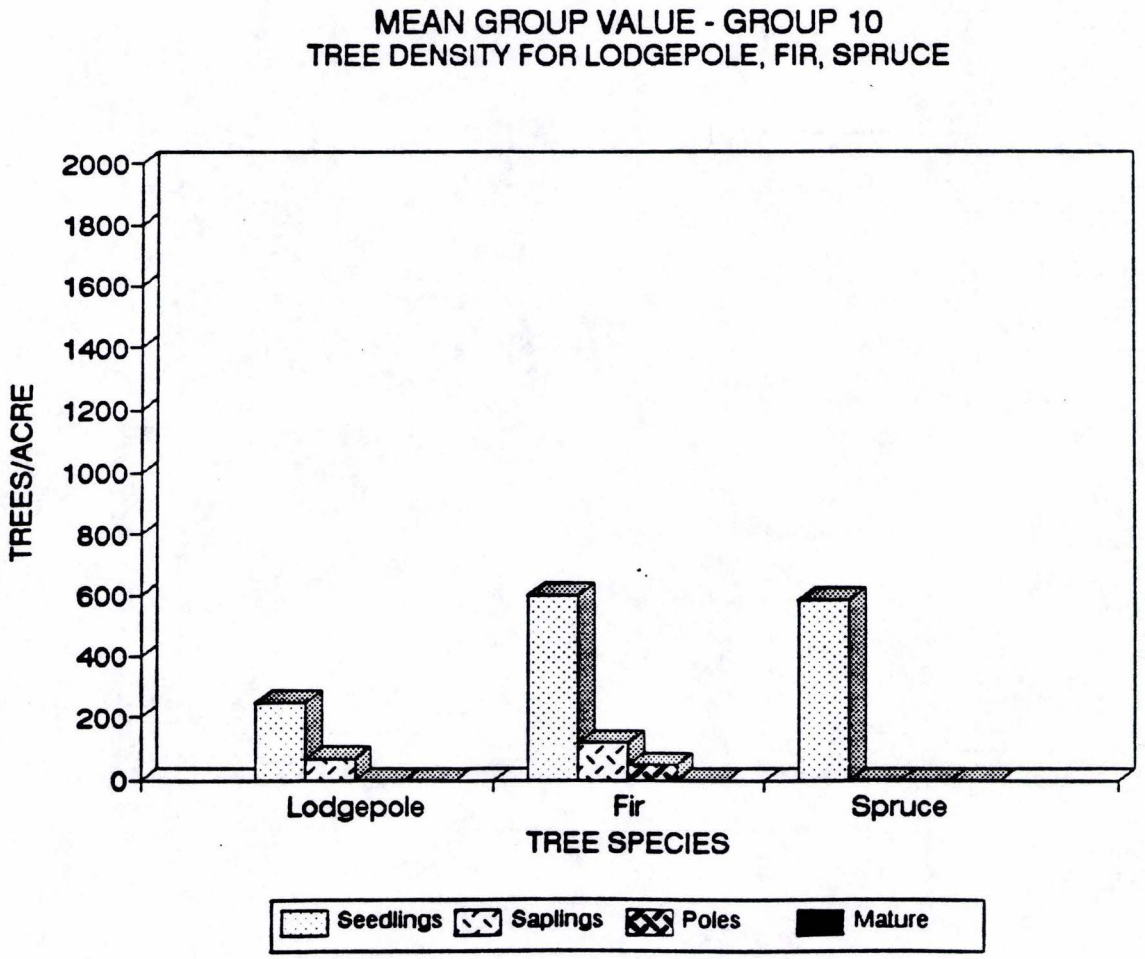


FIGURE AP16.7. Tree density for seedlings, saplings, poles and mature trees for three conifer species, Groups 10 and 11.

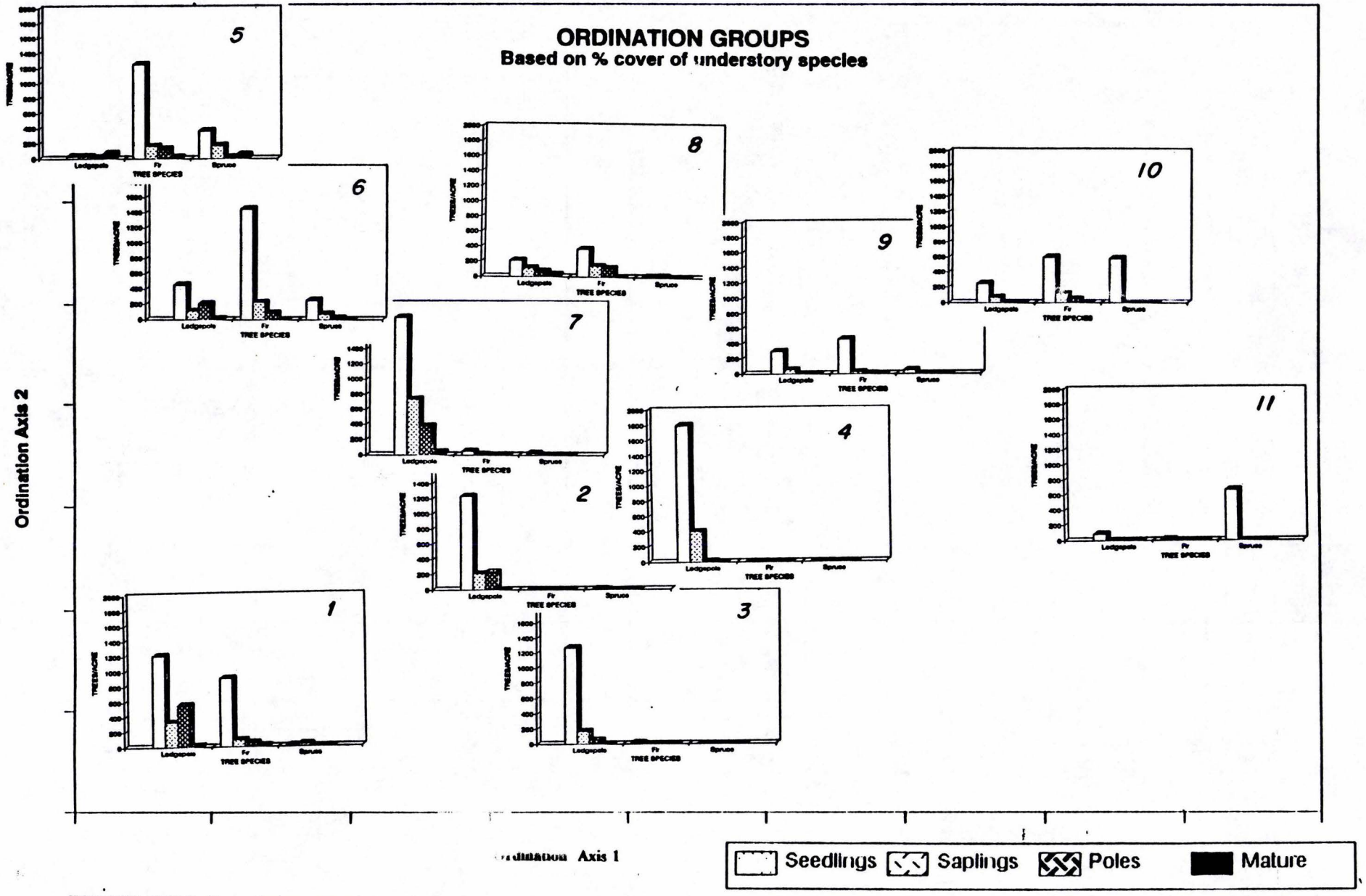


FIGURE AP16.8. Arrangement of tree size and density by Ordination Group.

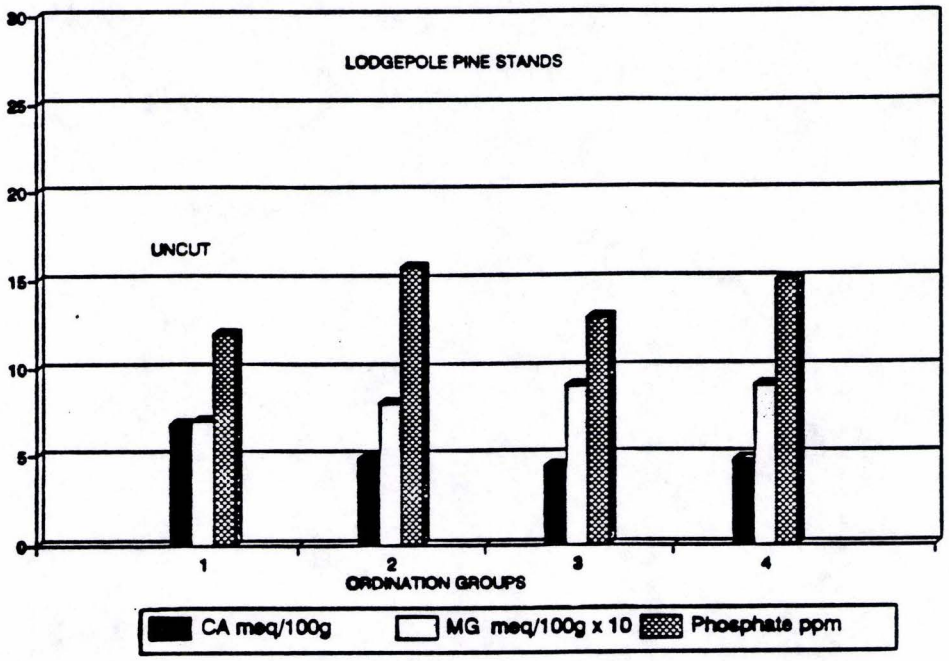


FIGURE AP16.9. Soil fertility in lodgepole pine stands.. Values of calcium, magnesium and phosphate for ordination groups in lodgepole pine stands. Quantity and pattern of all three soil chemicals are similar for the four Ordination Groups.

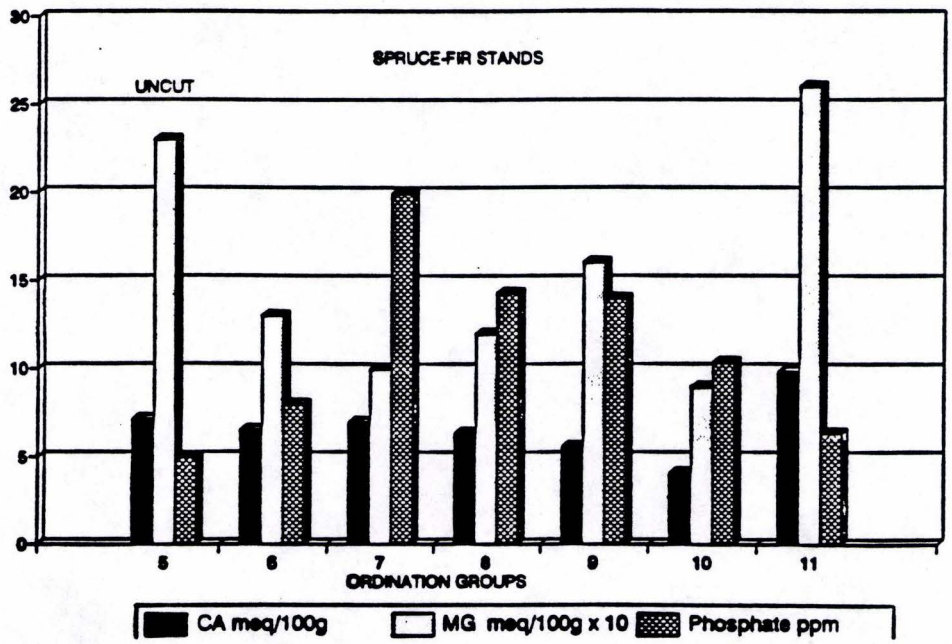


FIGURE AP16.10. Soil fertility in spruce-fir and mixed conifer stands. Values of calcium vary twofold and are about the same magnitude for lodgepole pine groups. Values for magnesium are higher and more variable than for lodgepole pine groups. Phosphate values for uncut, 1950s-uncut and riparian groups (5,6,10,11) are lower than for lodgepole pine groups. More recently cut stands have relatively high phosphate values.

APPENDIX 17

LAND MOSAICS - PATCHES AND NETWORKS

The following information is from the forthcoming book **Land Mosaics - The Ecology of Landscapes and Regions** by R.T.T. Forman of Harvard University. This is current, very pertinent information regarding landscape pattern and ecological processes. It has direct applicability to the proposed Old Growth Patch and Linkage System and to other spatial planning and management considerations.

Landscapes can be described in terms of patches and networks. Patches are subdivisions of landscape matrices. There are six basic configurations of patches and six basic network patterns formed by corridors. Networks facilitate flows of energy and materials through landscapes which have various kinds of patches. Borders between patches, or between patches and corridors, enable some kinds of flows and are barriers to others. Figures AP17-1 and AP17-2 show the basic forms of patches and corridors. Forman analyzed pattern formed by corridors with nodes using graph theory. Five basic spatial patterns are shown in Figure AP17-3.

Networks can be described by their density, connectivity and degree of circuitry (how many loops are present). Network connectivity appears to:

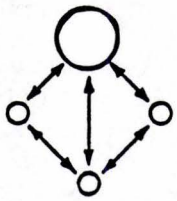
1. increase dispersal among local populations
2. decrease dispersal mortality
3. increase subpopulation growth rate due to recruitment, recolonization and natality
4. decrease variation in subpopulation size
   This has bearing on maintaining minimum viable populations.

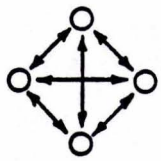
Networks function as habitat, as conduits, as filters, as sources of populations and as sinks for populations. An optimum network includes a high level of circuitry, a high variance in corridor width, has curvilinear links and has a high variance of mesh size. Mesh size refers to the average area or diameter of enclosed patches among corridors. Forman emphasizes that networks are not subsititutes for large natural vegetation patches.

Landscape matrices can be divided by corridors or perforated by patches. In extreme cases, the original landscape matrix can be converted to edge habitat dominated by edge species and processes and little if any interior habitat of the orignal matrix remains. Even with different patterns, approximatly 25% of areas in corridors and 75% in matrix gives essentially no interior area within patches. If about 40% is patches and 60% remaining matrix the interior area of patches is reduced to nearly zero. Combinations of corridor and

patch fragmentation will give other combinations of near zero interior area.

The behavior of populations colonizing or being extirpated from patches is called "winking". The best predictors of winking rates are patch size and interpatch distances. With regard to behavior of subpopulations and genetic characteristics, winking rates for two patterns of patches and linkages can be described as follows:





Subpopulation:		
Winking rate	Low	High
Local extintion rate	Low	High
Recolonization rate	Hi	Low
Genetic		
Inbreeding depression	Low	High
Strain disapperance, due to local extinction	Low	High
Strain disappearnce due to outbreeding influence	High	Low

Ecological values of large vs small patches are characterized by Forman as follows:

Large Patches:
- Water quality protection
- Connectivity of low stream order networks of headwaters
- Habitat for interior species
- Source of species for dispersal
- Microhabitat proximity for multihabitat species
- Natural disturbance regimes
- Buffer against extinction from environmental changes

Small Patches:
- Habitat stepping stones for dispersal and recolonization
- High species densities and high populations of edge species
- Matrix heterogeneity
- Escape cover
- Protects scattered small habitats and rare species

With regard to appropriate corridor width, Forman cites work by Harris et al (1991).

"1. When the movement of individual animals is considered and when much is known about their behavior, and when the corridor is expected to function in terms of weeks or months, then 10s of meters.

2. When movement of entire species is conisidered, when much is known about their behavior and when the corridor is expected to function in terms of years, then 100s of meters.

3. When entire assemblages of species are considered, when little is known of their biology and the corridor must function for for decades or centuries, then kilometers."

The proposed Old Growth Patch and Linkage System, which is a network of patches and linkages embedded in a highly fragmented matrix in the Medicine Bow Mountains, and in a less fragmented matrix in the Sierra Madre Mountains, has loop connections (circuitry) among source and sink areas, has high variance in linkage widths and mesh size and is curvilinear in character. The minimum width of most linkage areas is about a half mile, most are wider. Whenever possible, patches approach the shape of a circle or square which minimizes edge and maximizes interior area. There is already an abundance of edge in many areas, especially in the Medicine Bow Mountains.

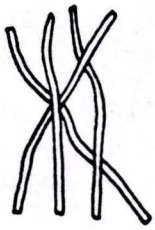
The research on fragmentation and connectivity patterns, flows of species through landscapes and population mainteneance, suggests that connection amon g large landscape patches with minimal edge is a prudent management strategy to maintain the kind of biological diversity associated with uncut, closed canopy forests.

LITERATURE CITED

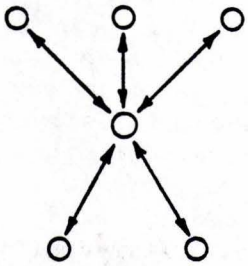
Forman, R.T.T. 1995. **Land Mosaics - The Ecology of Landscapes and Regions.** Cambridge University Press. (In Press).

Harris, L.D., and J. Schenck. 1991. From implications to applications: the dispersal corridor principle applied to the conservation of biological diversity. IN: D.A. Saunders and R.J. Hobbs (eds.) **Nature Conservation** (2) The Role of Corridors). Surrey, Beatty, Chipping. Norton, Australia.

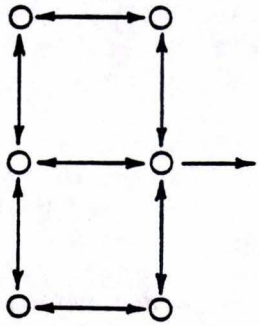
1. Corridor
   Rapid flows
   Tightly aggregated



2. Braided
   Slow flow
   Loosely aggregated

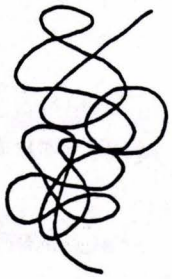


3. Plosion
   Strong source or sink



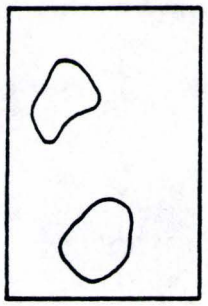
4. Rectilinear
   Weak source or sink

5. Dendritic
   Converging or diverging

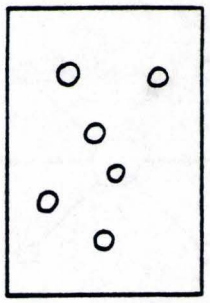


6. Irregular
   Individuals searching or meandering

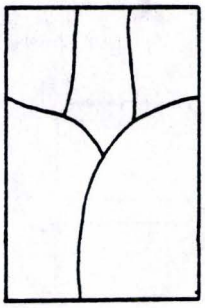
FIGURE AP17.1 Types and characteristics of networks. (Forman, 1995)



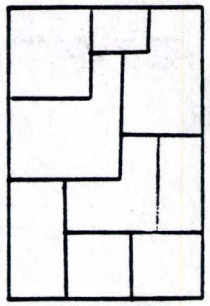
1. Large patches



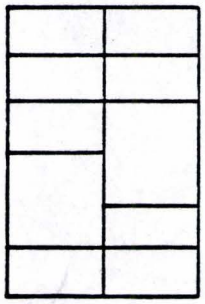
2. Small patches



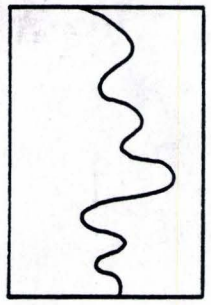
3. Dendritic patches



4. Rectilinear patches

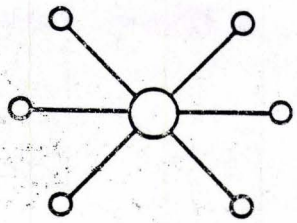


5. Checkerboard



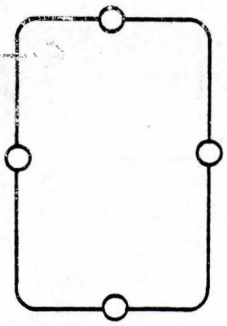
6. Interdigitated

FIGURE AP17.2 Types of patches. (Forman, 1995)

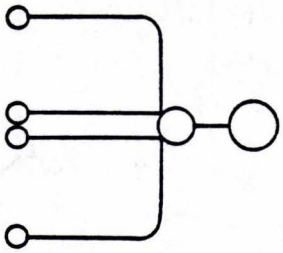


1. Spider

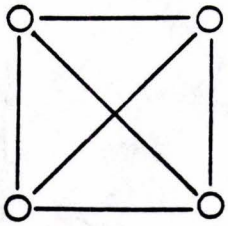
2. Necklace



3. Graph cell



4. Candelabra



5. Rigid polygon

FIGURE AP17.3 Types of spatial patterns (Forman, 1995)

Appendix 18

Descriptions of ECOMAP Preliminary Subsections

Subsections with Major Land Areas within NFS boundary

Most land areas of the MBNF are within the following Subsections. These preliminary Subsections for southern Wyoming (see Figure 3.3), were delineated by a Regional Working Group in January, 1995. A map of the Subsections is Figure 3.3 in Chapter 3.

Section M331I Northern Parks and Ranges

M331Iu - Park Range/Sierra Madre Subsection

Geomorphology. The Sierra Madre Mountains are at the northern end of the Park Range which extends northward from Colorado. Battle Lake is in a cirque valley, but most of the Sierra Madre Mountains were not glaciated. The Continental Divide splits the Park Range Subsection from NW to SE.

Lithology and Stratigraphy. The Sierra Madre Mountains consist of greater than 2.5 billion year-old granites, gneisses, and infolded metasedimentary and metavolcanic rocks unconformably overlain by a thick layer of 2.5 to 1.8 billion year-old metasedimentary and metavolcanic rocks. Nearly 2.0 billion years ago, this region was a continental coastline with volcanic islands, similar to the Asian-Japanese coast (Hausel, personal communication).

Soil Taxa. The subsection has frigid and cryic temperature regimes. Soils include Mollisols, Alfisols, Inceptisols and Entisols. Boralfs, Borolls, Ochrepts and Orthids are the predominant soil groups (Bauer et al. 1989).

Potential Natural Vegetation. Kuchler (1964) mapped the potential vegetation as western spruce-fir forest.

Fauna. Common mammals include elk and mule deer. Bighorn sheep have been reintroduced in the last 25 years. Pine marten, northern goshawk and black bear are found here. See Appendix 9, and Chapter 8 for lists and discussion of other fauna.

Climate. Mean annual precipitation ranges from about 14 inches per year at Encampment about 33 inches per year along the Continental Divide at Blackhall Mountain. Mean annual temperatures range from about 41 degrees to 32 degress at the same stations. The subsection receives heavy winter snow.

Surface Water Characteristics. Most streams are perennial. Streams on the west side of the Continental Divide are flood-prone in spring. Streams west of the Continental Divide in the Sierra Madre drain into the Colorado River System. Point source pollution from heavy metals exceeds State Water Quality standards in Haggarty Creek of the Little Snake River watershed (Gumtow et al. 1994).

Disturbance Regimes. Fire incidence from both man-caused and lightning-caused fires is low. Dwarf mistletoe and mountain pine beetle are found in lodgepole pine in localized areas. Spruce beetle infestations have also occurred in localized areas near Green Mountain (Schmid 1995).

Land Use. All NFS land in the Sierra Madre is in active grazing allotments. Except for two wilderness areas, most of the area is considered suitable for timber production. The Coon Creek project in the Sierra Madre in the Encampment River watershed is an experiment to determine the effects of creating small openings in subalpine forest on water yield. Western slope water from the Little Snake River watershed in the Sierra Madre is diverted to the Hog Park Reservoir to provide water for irrigation and to the City of Cheyenne, WY.

Cultural Resources. Several mining districts have historic interest.

M331Iv - Medicine Bow Mountains Subsection

Geomorphology. This area of uplift mountains is called the Snowy Range of the Medicine Bow Mountains. Geomorphic features include glaciated alpine and subalpine areas above 10,000 feet, kettleholes and alpine lakes, deep canyons with high gradient streams, low hills and mountains and a high elevation erosional surface. Elevations range from 7000 to 12,000 feet.

Lithology and Stratigraphy. The area has complex lithomorphic units including Precambrian granite, metamorphosed sedimentary and volcanic rocks, and mafic intrusive rocks (Love and Christiansen 1985).

Soil Taxa. The subsection has frigid and cryic temperature regimes. Soils include Mollisols, Alfisols, Inceptisols and Entisols. Boralfs, Borolls, Ochrepts and Orthids are the predominant soil groups (Bauer et al. 1989).

Potential Natural Vegetation. Kuchler (1964) mapped the potential natural vegetation of both the Sierra Madre and higher elevations of the Snowy Range as western spruce-fir forest. Lower elevations of the Snowy

Range were mapped as Douglas fir forest. See Appendices 4 and 6 for further information on flora and community types.

Fauna. Common mammals include elk and mule deer. Bighorn sheep and moose have been reintroduced in the last 25 years. Pine marten, northern goshawk and black bear are found in the area. See Appendix 9 and Chapter 8 on fauna.

Climate. Mean annual precipitation ranges from about 14 inches at Sheep Mountain to about 50 inches near Medicine Bow Peak. Mean annual temperatures range from about 41 degrees F at Centennial to 31 degrees F near Medicine Bow Peak. See Appendix 3 for further information on climate.

Surface Water Characteristics. Most of the annual precipitation occurs as snowfall from November to April. Snowfall is heavy in high elevations of the Snowy Range. Snowfall is light to moderate in the southern part of the Medicine Bow Mountains around Foxpark. Rob Roy Reservoir and Lake Owen are part of the Cheyenne Water System. Streamflow is highly variable and responsive to snowpack and snowmelt conditions. All streams in the Subsection are in the North Platte watershed. The North Platte River flows through the Platte River Canyon and Wilderness area in the southwestern Medicine Bow Mountains.

Disturbance Regimes. Man caused fires are the major disturbance in the Medicine Bow mountains. The background rate of lighting-caused fires is fairly low. Windthrow of trees occurs periodically especially on northerly and westerly slopes in the northern portions of the subsection. Dwarfmistletoe and comandra blister rust are the major forest diseases. Moutain pine beetle and spruce beetles are present but tend to remain at low infestation levels.

Land Use. Two wilderness areas and one Research Natural Area (Snowy Range - 771 acres) are in the MBNF portion of this subsection. Most of the area outside the wilderness and RNA is considered suitable for timber harvest. There are some areas allocated to wildlife habitat management emphasis. Several vacant grazing allotments occur near Medicine Bow Peak and Rob Roy Reservoir. Both sheep and cattle allotments are permitted. There is a downhill ski area southeast of Medicine Peak. Cross country skiing and snowmobiling are popular winter sports in both ranges. The Snowy Range Highway is a National Forest Scenic Byway.

Cultural Ecology. Archeological excavations have been done at Sand Lake. Few other archeological sites are known to occur the Subsection, but additional study is needed. Most watersheds were tie-hacked between 1867 and World War II.

M331Ib - North Front Range Subsection

Geomorphology. This subsection includes the Sherman Mountains east of Laramie, WY. In the Sherman Mountains, the eastern part of the uplift is buried under Oligocene tuffaceous claysone and arkosic conglomerate. Granitic rocks often abut Paleozoic sandstones or limestones at the western edge of the Subsection. Streams are small and ephemeral, except for Crow Creek which carries water transported to its headwaters by pipeline from the western slope as part of the City of Cheyenne water supply. Elevations ranch from 7500 to 9000 feet in the Sherman Mountains.

Lithology and Stratigraphy. The characteristic geological substrate is Sherman granite and Laramie anorthocite of Middle Proterozic origin (Love and Christiansen 1985). This region also includes several Early Devonian kimberlite diatremes and dikes. Unconsolidated quaternary alluvium is associated with Sherman granite in many areas.

Soil Taxa. Temperature regimes in this subsection are mainly mesic and frigid. Predominant soils are Mollisols and Alfisols. Borolls, and Orthids are common (Edwards 1989).

Potential Natural Vegetation. Kuchler (1964) mapped the potential natural vegetation as pine/Douglas fir forest.

Fauna. Animals characteristic of montane and lower subalpine ecosystems are found here. Large mammals include elk, mule deer and antelope. See Appendix 9 and Chapter 8 for additional information.

Climate. Mean annual precipitation ranges from about 12 inches per year at Pole Mountain to 16 inches at Sybille Canyon. Mean annual temperature ranges from about 34 degrees F to 41 degrees F for the same stations. See Appendix 3 for more detail.

Surface Water Characteristics. Surface water is very limited. Springs are not common and most streams are small. Many are ephemeral. The flow in Crow Creek is augmented from the Cheyenne Water supply system. Streams drain into the South Platte watershed. Stream which drain the west edge of the Pole Mountain Unit (Laramie Ranger District) into the Laramie Plains are Subsection 342Ff.

Disturbance Regime. Man-caused and lighting-caused fires are of approximately equal occurrence in the Sherman Mountains, but the total number of fires is low and so is the acreage burned. See Appendix 14 for more information. No serious infestations of insects or other forest parasites are known.

Land Use. In the Sherman Mountains, cattle grazing and recreation are the dominant land uses. It is a popular area for camping and cross country skiing.

Cultural Ecology. The Sherman Mountains were a source of telegraph poles, railroad ties and cordwood for steam engines during the period 1860-1885. Crow Creek was the route of early trails (1840s) and probably a travel route for Native Americans for many centuries.

M331Ic - North Laramie Mountains Subsection

Geomorphology. This subsection includes NFS lands on uplift mountains north of Sybille Canyon not including the Casper Mountain area. The southern part is dominated by Laramie Peak (10,272 feet). Unconsolidated quaternary alluvium and Oligocene sediments border the subsection and are found as patches within the subsection. Topography varies from extremely rugged, deep canyons and steep-sided mountains to rolling uplands where alluvium has buried the granite. The northern part of the Laramie Mountains is less rugged, with most peaks at about 9000 feet. On the west side, the subsection borders the Shirley Basin and Oligocene sediments abut the uplift rocks. Elevations range from about 6000 feet to 10,000 feet.

Lithology and Stratigraphy. The Laramie Mountains are formed of very old Precambrian rocks (Late Archaen Age). They are composed of granite, amphibolite, and metasediments intruded by Proterozoic diabase dikes (Love and Christiansen 1985).

Soil Taxa. The subsection has frigid and cryic temperature regimes. Soils are predominantly Mollisols and Alfisols. Entisols occur along stream valleys (Edwards 1992).

Potential Natural Vegetation. Kuchler (1984) mapped vegetation as pine/Douglas fir forest. The northern end has mostly lodgepole pine and limber pine, while the southern half has mostly lodgepole pine and

ponderosa pine. Douglas fir is found on north facing slopes of La Bonte Canyon. The Laramie columbine, *Aquilegia lariamensis,* is endemic in the vicinity of Laramie Peak.

Fauna. This subsection has elk, mule deer, bighorn sheep and antelope. Black bear, mountain lion and bobcats are hunted. See Appendix 9 and Chapter 8 for additional information.

Climate. Mean annual precipitation ranges from about 14 inches per year at the Double-4 Ranch on the Laramie River to an estimated 25 inches on Laramie Peak. Mean annual temperature ranges from about 43 degress F to an estimated 32 degrees F for the same stations. Most moisture is received from March to May.

Surface Water Characteristics. All streams drain either directly into the North Platte River or into the Laramie or North Laramie Rivers which are tributary to the North Platte. Larger streams are subject to heavy spring and summer flows and flash flooding. Smaller streams are often ephemeral. Springs are of limited occurrence. The Laramie River and Horseshoe Creek flow through deep canyons. There are no major reservoirs or water projects in these mountains.

Disturbance Regimes. Lightning-caused fires are more frequent than man-caused fires. From 1988-1994 there was an epidemic of mountain pine beetle (*Dendroctonus ponderosae*) in ponderosa pine trees in the southern part of the NFS lands. There are no other major tree diseases.

Land Use. Private and state lands are highly intermingled with NFS lands in this subsection. The Laramie Peak area and LaBonte Canyon area are the largest contiguous areas under NFS ownership. Cattle grazing and wildlife habitat are dominant land uses. Salvage logging occurs in the

Laramie Peak area. Some commercial lodgepole pine/spruce-fir harvest occurs in the northern portion of the Laramie Mountains.

Cultural Ecology. Scattered areas of Indian Artifacts are found throughout the Laramie Mountains. Archeology is not well-known.

Central Basin and Hills Section (342F)

342Fd - Savory-Saratoga Valley Subsection

Geomorphology. This area includes the transition into the Washakie Basin to the west and north of the Sierra Madre, and the area west of the Medicine Bow Mountains in Wyoming. Land surfaces consist of slightly dissected hills, shallow canyons, wide valleys and escarpments consisting of intrusive volcanics. Outside the National Forest Boundary are tablelands.

Lithology and Stratigraphy. Geologic substrate consists mainly of Cretaceous and Miocene sedimentary Rocks with basalt flows and igneous intrusives in the southwestern portion. This includes Battle Mountain, lower Battle Creek Valley, portions of the Little Snake watershed and most of Big and Little Sandstone Creek along the western part of the Sierra Madre. Basalt flows and intrusive igneous rocks are found in the Battle Mountain area.

Soil Taxa. This section has mostly frigid and cryic temperature regimes. Soils are mainly Mollisols and Alfisols. Most soils are Cryoborolls, Cryoboralfs or Cryaquolls. Many soils are highly erodible in this subsection.

Potential Natural Vegetation. Kuchler (1964) mapped the vegetation as western spruce-fir forest. See Appendics 4-6 for further information on flora and plant communities.

Fauna. Common large mammals include elk and mule deer. Colorado River cutthroat trout occurs in some watersheds west of the Continental Divide. See Appendix 9 and Chapter 8 for further information.

Climate. This is the mildest area in the Medicine Bow National Forest. Mean annual temperatures range from an estimated 35 degrees F near Baggs to about 42 degrees F at Columbine, Colorado. Mean annual precipitation amounts range from about 11 inches to 25 inches for the same stations. See Appendix 3 for more information.

Surface Water Characteristics. Most streams are perennial, fed from ample snowpack along the Continental Divide. Streams are subject to high spring flows which can cause severe bank erosion and siltation of stream beds. Some of the areas in the Little Snake River drainage have been impacted by construction of the Cheyenne Stage II pipeline. See Photos H15-18 in Chapter 5.

Disturbance Regimes. Large fires in 1841 removed most of the coniferous forest. Aspen is presently the dominant species. Although the shrubby ecosystems on the hillslopes and in the valleys are fire-prone and fire adapted, few fires have occurred in the past 100 years. Lightning-caused and man-caused fires occur at low frequencies in approximately equal proportions.

Land Uses. The primary land use is grazing. Wildlife habitat and recreation are two other important uses.

Cultural Ecology. The fires of 1841 are believed to have resulted from conflict among Indians and fur trappers. Archaeology is not well-known.

ECOMAP Preliminary Subsections with Minor Land Areas within the NFS Boundary.

Five additional Subsections with small areas of NFS land border the four major Subsections bearing the majority of the mountain areas of the Medicine Bow National Forest. Three of these are within the Mountain Province (M331) and three are in the Intermountain Semi-Desert Province (M342). Brief descriptions are provided.

Northern Parks and Ranges Section (M331I)

M331Ie - Rolling High Plains Subsection

This subsection is characterized by Oligocene rocks and unconsolidate Quaternary sediments which form broad, gently rolling plains which slope upward from the North Platte River to the mountains over distances of 30 to 50 miles. These plains are about 4000-6000 feet in elevation and support mixed grass prairie with western wheatgrass, blue grama, needle-and-thread, numerous forbs and small shrubs. They are in private and state ownership, managed by large ranches.

M331If - North Front Range Foothills Subsection

This transitional area between the uplift mountains and the Central High Plains Section (331H) contains broad, gently rolling plains underlain by Oligocene rocks, outcrops of Palezoic sandstones and limestones and local areas of metasedimentary rocks of schist, marble, gneiss and amphibolite (Love and Christiansen 1985). The dominant land use is cattle ranching.

Central Basin and Hills Section (342F)

342Fe - Shirley Basin Subsection

Very limited portions of the Shirley Basin Subsection are found at the northern and western edge of the Laramie Mountains. These consist of Tertiary conglomerates found in the Little Medicine Bow River watershed west of LaPrele Pass. The conglomerates form shallowly dissected tablelands covered with grasses and sagebrush.

342Ff - Laramie Basin Subsection

Portions of the Laramie Basin Subsection border the east edge of the Medicine Bow Mountains and the western edge of the Sherman Mountains. The substrate below the plains is quaternary deposits. Paleozoic sedimentary rocks (sandstone and limestone) lie against the granite of the uplift mountains. They form hogbacks which can be seen west of Centennial, near the northeastern edge of the Medicine Bow Mountains, along the base of Sheep Mountain and at the western edge of the Pole Mountain area. The dominant vegetation on these substrates includes mountain mahogany, bitterbrush, sagebrush, bunchgrasses, ponderosa pine and limber pine.

342Fg - Hanna Basin Subsection

This subsection is composed of Paleocene and Eocene sandstone, shale and conglomerates which distinguish it from the Central Rocky Mountains, the Laramie Plains (Quaternary deposits) and the Saratoga-Red Desert (Cretaceous and Miocene rocks). Coal deposits are found near the town of Hanna. Vegetation in this semi-arid area is mostly dry shrubland (sagebrush, greasewood) and grasses.

LITERATURE CITED

Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States. Special Publication 36, New York, New York. American Geographical Society.

Bauer, A.; Edwards, M; Hudnell, L. 1989. Soil Survey of the Medicine Bow National Forest, Wyoming. Medicine Bow Moutains and Sierra Madre Mountains Area. (Draft Report) USDA Forest Service, Laramie, WY

Edwards, M. 1989. Soil Survey of the Pole Mountain Area, Medicine Bow National Forest, Wyoming. (Draft Report). USDA Forest Service Laramie, WY.

Edwards, M. 1992. Soil Survey of the Laramie Peak Unit, Medicine Bow National Forest, Wyoming. Survey Area 622 (Interim Report 4/92) Medicine Bow National Forest, Laramie, Wyoming

Gumtow, R; DiRienzo, B; Frederick, K. 1994. 1994 Wyoming Water Quality Assessment. Water Quality Division of the Wyoming Department of Environmental Quality. Cheyenne, WY.

Love, J.D.; Christiansen, A.C. 1985. Geologic Map of Wyoming. USGS

Schmid, J. 1995. Personal communication. USFS Research - retired.

APPENDIX 19

CHRONOLOGIES OF HISTORICAL EVENTS

Tables AP19.1 through AP19.6 are chronologies of events which have affected vegetation and animal populations, circumscribing biological diversity of the Medicine Bow National Forest since 1800. Specific references for information in the tables are numbered and listed at the end of the tables. Additional discussion on all topics is found later in the report. All information is from published work, or unpublished records available in the Medicine Bow Collection at the American Heritage Center, University of Wyoming. The Medicine Bow Collection consists of 32 boxes of documents and photographs on loan to the American Heritage Center from the Medicine Bow National Forest.

Forest Archaeologists Jim Heid and Deana Wood, have organized historical information, particularly on tie hacking and prehistoric sites, trails, mining and fire detection (Wood 1988; also Historical Section of Appendix 1). The chronologies presented below are excerpted from about 2000 pages of historical documents and give a synopsis of human interaction with the plants and animals of the MBNF in the last 200 years.

Table AP19.1 Historical Overview

Division	Age span	Events
Before 1800	>195 years	Most human influence was from Native Americans. Some fur trapper activity
1800-1849	194-155 years	Fur trappers Smallpox epidemics decimated Indian populations Limited travelways Prior to: California gold rush, Civil War, Homestead Act, Indian Wars, telegraph, railroad
1850-1910	154-84 years	Time of accelerated change due to westward expansion - tie hacking, settlement, towns, Oregon Trail, Overland Trail, Indian Wars, Fort Sanders, first livestock, widespread stocking of exotic fish in N. & S. Platte drainages, mining, commercial game hunting, rapid population growth, extermination of some native species widespread forest fires
1911-1949	83-45 years	Forest Service management of timber operations and grazing, fire suppression, building of roads, building of railroad through the Foxpark area, hunting controls, wildife management, stocking of exotic fish in Snowy Range Lakes & Little Snake drainage, animal damage and predator control, timber demand mostly for ties and mine timbers, selective cutting
1950-present	44 - 0 years	Post World War II population boom, demand for sawtimber products, water developments, building of roads, use of large haul trucks, clearcutting, continued fire suppression, Wilderness areas, Research Natural Area, Threatened, Endangered and Sensitive Species consideration in Planning and Management, increased recreational uses

Table AP19.2 Medicine Bow National Forest Organizational Chronology

DATE	EVENT*
1900	Crow Creek Forest Reserve (Sherman Mountains)
1902	Medicine Bow Forest Reserve (Colorado and Wyoming)
1906	Sierra Madre Forest Reserve (Colorado and Wyoming)
1908	Cheyenne National Forest formed (includes Crow Creek Reserve and Wyoming portion of Medicine Bow Reserve)
1908	Hayden National Forest formed
1910	Medicine Bow National Forest (name change) Crow Creek Division transferred to War Dept.
1924	Sheep Mountain National Game Refuge added to Medicne Bow National Forest
1929	Sierra Madre portion of Hayden NF added to Medicine Bow National Forest
1935	Laramie Peak Division (Laramie Mountains) added to Medicine Bow National Forest
1961	Crow Creek Division returned to MBNF
1995	Pending consolidation of Medicine Bow National Forest and Routt National Forest
*	These are offical events of public record

Table AP19.3 Forest Fires noted in the Historical Records*

Before 1873	Sevenmile, North Fork, 3 Mile
1868	Pole Mountain, Libby Flats
1870	Baldy Mountain, Cedar Creek
1892	Chimney Park, Cow Creek, Calf Creek, Fox Creek, Spring Creek
1896	Devil's Gate
1900	Porter Creek
1901	Sevenmile
1923	Devil's Gate fire
1924	LaPrele Creek
1931	Toltec fire
1934	LaPrele Creek

(For fires after 1945 see Appendix on Fire History)

* This is not a complete list, but shows locations of some of the larger fires.

Table AP19.4 Medicine Bow National Forest chronology of events 1838-1899.

1838	Fraeb's trading Post - Sierra Madre (1)
1841	Battle of Fraeb with Indians. Battle Mtn. fire (1)
1842	Fremont's expedition (Sherman Mts.) (1)
1846	Parkman's expedition (Laramie Mts.) (2)
1846	The Grande Encampment (3)
1850	Captain Stansbury's expedition (Sherman Mts.) (1)
1860's	Cooper (British sportsman) (4)
1861	gold discovered on Douglas Creek (5) Overland Stage Overland Telegraph completed (6)
1866	Al Huston ranches Laramie Plains (4)
1867	First tie camps - Coe and Carter (3) Sherman Hills stripped for ties and cordwood (1)
1868	Sherman Hills (Pole Mountain fires) (7) Libby Flats fire (Engelmann Spruce) (7)
1869	Union Pacific Railroad completed First trout brought to N. Platte tributaries (7)
1870	Tie cutters not paid until fire season was over incentive to use care (3) First portable steam sawmills (3) Big fires in Northern Medicine Bow (3) Fires set to drive cattle out (Douglas Creek) (8) Last buffalo killed by Utes
1875	Trains began using coal instead of cordwood mine props become an important product (1)
1880	Fort Fred Steele Wood Reservation (1880-1884) at N. end of Medicine Bow Mts. (3) First Fish Commissioner plants rainbow trout near Jelm (7) Sheep grazing becomes important - beginning of cattle and sheep conflicts (3)
1881	All accessible streams in Albany, Carbon and Laramie Counties planted with non-native fish (7)
1884	Railroad car of fish wrecked near Fort Fred Steele - all fish dumped into N. Platte (3) (7)
1890	Gold mining important. Placer mining on Savery Creek, Jack Creek, North Spring Creek (1) (9)
1892	Many fires - Chimney Park (7), Cow Creek, Calf Creek (10)
1893	Blowdown event - 3 miles wide and 8-10 miles long beginning 3 miles east of Brush Creek tie camp and extending over the range (11)

Table AP19.4 continued

1894	Non-native trout placed in high altitude lakes in Snowy Range (12) Formation of "dead line" in Sierra Madre to separate sheep and cattle ranges (13)
1895	Most wolves exterminated by poisoning (6) Beginning of Carbon Timber Company - cut 52 MBF 1896-1902 Heavy cutting on Encampment River watershed (3)
1896	Last antelope seen in Big Hollow on the Laramie Plains (4) Last elk migrate between the Laramie Mts. and Sheep Mtn. (7) Devils' Gate fire (7)
1898	State Game Commissioner desperately calls for hunting regulations (7)

References for Table AP19.4

1 Thybony, S., Rosenberg, R.G. and E.M. Rosenberg. 1985. The Medicine Bows - Wyomings Mountain Country Caldwell Idaho Caxton Press

2 Parkman, F. 1950. Chapters 13, 17, 18, 19 IN: The Oregon Trail. New York. Mentor Books.

3 Mullison, J.H. 1909. Report for the Forest Atlas. Administrative Report for the Medicine Bow National Forest. Medicine Bow Collection. American Heritage Center. University of Wyoming.

4 Coughlin, L.E. 1926. Memorandum for Files - Historical Data. Medicine Bow Collection.

5 Duthie. G.A. 1915. Letter from Supervisor Duthie to District Forester on history on Medicine Bow National Forest. Medicine Bow Collection

6 Willshon, B. 1927. Historical Information Report by Bernard Willshon (Annual Report of District Forest Ranger - Bow District) Medicine Bow Collection

7 Medicine Bow National Forest. 1951. Reference File - Historical. Medicine Bow Collection

8 Smith, F.C. 1925. Historical information submitted to Medicine Bow National Forest in 1924 as part of effort to obtain historical information. Medicine Bow Collection

9 Blackhall, J. 1915. Supervisors's Administrative Report for Historical file on Hayden National Forest. Medicine Bow Collection

10 Saratoga Sun Newspaper. 1932. Forty Years Ago in Saratoga. (From Saratoga Sun and Platte Valley Lyre August 25, 1982)

11 Saratoga Sun Newspaper. 1933. Forty Years Ago in Saratoga (From Saratoga Sun and Platte Valley Lyre October 26, 1893)

12 Saratoga Sun Newspaper. 1934. Forty Years Ago in Saratoga. (From Saratoga Sun and Platte Valley Lyre August 30, 1894)

13 Blackhall, J. 1909. Report for the Forest Atlas (Hayden National Forest) Medicine Bow Collection

Table AP19.5 Medicine Bow National Forest chronology of events 1900-1949.

1900	Bighorn sheep populations decline due to diseases of domestic sheep (3)
	Crow Creek Forest Reserve created (1)
1902	Carbon Tmber Company cuts 55 MBF (1896-1902) in Encampment River watershed (9)
	Carbon Timber Company cuts 33 MBF from Northern Medicine Bow Mountains (3)
	20 townships destroyed by extensive fires (14)
	Beaver populations very low (7)
	President Roosevelt asks Congress for legislation to protect game in Forest Reserves (7)
	Creosote tie treating plant in Laramie (1)
1905	Fish planted in Telephone and Towner Lakes in Snowy Range. Sheep outfits helped pack fish in - suckers, grayling, non-native trout (7)
	First grazing fees (5)
1906	Hayden National Forest created
1907	lst enforceable Wyoming Game Laws (3)
	lst petition to add Sheep Mountain to MBNF (15)
	Laramie, Hahn's Peak and Pacific Completed from Laramie to Centennial (44)
1908	Hahn's Peak and Pacific Railroad built to Centennial (1)
	Rest-roatation grazing tried in Sierra Madre (13)
	Public Law 136 - Forest Officers begin to protect fish and game (7)
	Laramie, Hahn's Peak and Pacific Railroad reaches Albany (44)
1909	83,000 acres burned over. Forest Administration decides that 10 to 15 MBF is sustainable level - based on an estimate of 200 billion board feet and a rotation of 200 years - forest is presently heavily overcut (3)
	Recommendation not to cut ponderosa pine in the Medicine Bow and Sierra Madre (16)
1910	First fire lookout - Medicine Bow Peak Not over 50 acres lost to fire since 1903. (3)
	Laramie, Hahn's Peak and Pacific Railroad reaches Coalmont, CO in North Park (44)
1911	Range descriptions include many weedy species - yarrow, knotweed, geranium, potentilla yelloweed (**Senecio eremophilus**) (17)
	concern over poisonous plants - false hellebore, lupine, larkspur (17)
	Brome and timothy (exotic grasses) seed on sheep ranges (17)

Table AP19.5 continued

1912	Recommended intermittent grazing during growing season and rest for dry grasslands every 3 years. Cinnibar Park - weedy and overgrazed (18) 60 elk brought from Jackson Hole and released in French Creek-Brush Creek area (7)
1913	Sierra Madre - all available areas used for permitted stock, even to detriment of watersheds. Recommended closing high country to sheep to protect watersheds.(19) For timber sale marking - X% to be cut and Y% left in various size classes. Attention to stand structure and windthrow risk (20)
1914	Timber output governed by Union Pacific demand for lumber and ties (9)
1915	Sierra Madre - "The forest is fully stocked with cattle and sheep. It is not, in any sense, a recreation forest at the present time" (9) Timber supply on private land being rapidly exhausted (21) Forest officers kill bear, coyote, lynx and wolves (5) More elk imported (5).
1917	Union Pacific goes to double tracks - increase in demand for ties (7).
1920	Debate as to whether bears were predators or game animals (problems with bears and sheep) (7) Grizzly bear seen in northern Medicine Bow Mts (22).
1921	Attempts to introduce plant life to alpine lakes to provide food for stocked fish (24) Continued grizzly bear reports - Rock Creek/Carlson Creek area (25) Poisoning of pocket gophers (23).
1922	Addition of Laramie Peak District proposed First courses at the Snowy Range Science Camp Special use permit issued in 1927.
1923	Supervisor Hilton writes: " Is the time approaching when the picturesque tie hack with his broadaxe will be replaced by a sawmill on wheels? The experiment of manufacturing ties with such a sawmill driven by a Fordson is to be given a thorough try-out next spring in the Foxpark Region of the Medicine Bow National Forest" (7). Grizzlies seen near Pass Creek and Sand Lake Road (25).

Table AP19.5 continued

1924	Sheep Mountain Game Refuge becomes part of Medicine Bow National Forest August, 1924 Coughlin apprehends elk poachers on Sheep Mountain.(26) Dutton Creek timber sale - first sale where trucks were used extensively (27).
1925	Pole Mountain Unit (formerly Fort D.A. Russell Target and Maneuver Reservation becomes part of MBNF. 8 Kaibab deer imported for stocking (28). Lion hunters employed to extirpate lions in the southern Medicine Bow Mountains (Sheep Mtn, Fox Creek, Devils Gate, Jelm, Douglas Creek) (29) Poison used against coyotes on Pole Mountain (28). More elk imported. Right of way laid out for automobile road from Wood's Landing to Mountain Home (7)
1926	Construction of Snowy Range Highway completed (1)
1928	Suggestion to use kettlehole area in Turpin drainage for moose reintroduction area (30) NW Medicine Bow - bear, lynx, lion, wolf, marten (30) Laramie Chapter of Izaak Walton League organized (7) Beaver transplanted to Pole Mountain. Bighorn Sheep transplanted to Sheep Mountain (7) 7 1/2 million fry planted forestwide (7)
1929	Hayden Division added to Medicine Bow National Forest Spruce budworm outbreak in Douglas fir along N. Platte River (31)
1931	Range Management Plan for Sierra Madre "Grazing should be subservient to timber production and watershed protection and should also give way within reasonable limits to the protection of wildlife and to recreational uses" Past permitting levels were too high (32).
1932	Work on biology of fish (1925-1938) done in cooperation with University Summer Science Camp (7)
1933	Winter range depleted on west side of Medicine Bow Mountains due to drought (33)

Table AP19.5 concluded

1935	Laramie Peak Division added. Issues were fair administration of grazing and fire protection. Beavers were abundant, sheep were main type of stock.(7)
	Merriams turkeys introduced to Laramie Peak area in trade for sage grouse with New Mexico Fish and Game Department (7)
	Goshawks considered a menace toward game birds (34)
	Six fire lookouts on in the Medicine Bow Mountains and two in the Sierra Madre.(1)
1936	Lack of good winter range is main limiting factor for elk and deer populations. Estimated 30 elk and 450 mule deer on Brush Creek District. (35)
	Snowy Range Research Natural Area set aside (771 ac)
1937	Construction of Little Brooklyn Lake (retaining pond) This and many other fish construction projects occurred with CCC labor in the 1930s) (36)
1938	Beaver transplants recommended in Laramie Mountains - active beaver management program through mid-1940s under Deputy Game Warden William Lakanen. (37)
	First raccoons on MBNF (36)
	Sixteen bears killed in Snake River area of Sierra Madre (36)
	Fears among stockmen "Stockmen generally are apprehensive that eventually livestock are to be excluded from the National Forest for the benefit of game and recreation". (36)
1939	Chukar stocked in Bates Hole area - observed in LaPrele watershed the following year. (38)
	Big game populations high - 16,000 deer or MBNF (38)
1940	Last tie drive on Douglas Creek - Union Pacific discontinued purchase of of hewed and river-driven ties (7)
	Lynx may no longer be on the MBNF(38)
	Too many beaver in many areas - Government trapping begins. (38)
1942	Forest policy - "brushing in" of skid trails not necessary to control erosion.(39)
	Poaching assumes enormous proportions - beaver pelts bring $60.00 each (legitimate) and $90.00 in the black market.(7)
1945	Deputy Game Warden William Lakenen murdered by beaver poachers - end of beaver management program (7)
1946	REA needs power poles 144,000 cut (7)
1949	Overpopulation of deer and elk - destruction of browse and range. Severe winter lowers numbers. (7)

Table AP19.6 Medicine Bow National Forest chronology of events 1950-1993.

1949	First Research Station Paper on Alternate clear-strip cutting in the lodgepole pine type (45)
1952	50th anniversary of Medicine Bow National Forest MBNF advertises 83 MBF to be sold 1952-1962 in the Rock Creek Watershed (27)
1954	Water becomes an important managed resource.(40) 93 beavers removed from Pole Mountain to control populations (40) 18,500 deer (40) 252,000 fish planted (40) 350 miles of roads (40) 16 fire lookouts (40)
1960	Towner Lake Tornado July 4, 1960 Trees uprooted (41)
1964	Completion of Stage I - Cheyenne Water Development Plan
1965	Completion of Hog Park and Rob Roy Reservoirs (1)
1967	Comment from forester who marked timber in 1906 that "clean-cutting would make much waste of the smaller trees"(42) Timber market has shifted from ties to studs (43)
1978	Savage Run Wilderness Area designated
1982	Commencement of Stage II - Cheyenne Sater Project
1984	Designation of Platte River Wilderness, Huston Park Wilderness and Encampment River Wilderness

References for Tables AP19.5 and AP19.6

1 Thybony, S., Rosenberg, R.G. and E.M. Rosenberg. 1985. **The Medicine Bows - Wyomings Mountain Country** Caldwell Idaho Caxton Press

2 Parkman, F. 1950. Chapters 13, 17, 18, 19 IN: **The Oregon Trail.** New York. Mentor Books.

3 Mullison, J.H. 1909. Report for the Forest Atlas. Administrative Report for the Medicine Bow National Forest. Medicine Bow Collection. American Heritage Center. University of Wyoming.

4 Coughlin, L.E. 1926. Memorandum for Files - Historical Data. Medicine Bow Collection.

5 Duthie. G.A. 1915. Letter from Supervisor Duthie to District Forester on history on Medicine Bow National Forest. Medicine Bow Collection

6 Willshon, B. 1927. Historical Information Report by Bernard Willshon (Annual Report of District Forest Ranger - Bow District) Medicine Bow Collection

7 Medicine Bow National Forest. 1951. Reference File - Historical. Medicine Bow Collection

8 Smith, F.C. 1925. Historical information submitted to Medicine Bow National Forest in 1924 as part of effort to obtain historical information. Medicine Bow Collection

9 Blackhall, J. 1915. Supervisors's Administrative Report for Historical file on Hayden National Forest. Medicine Bow Collection

10 Saratoga Sun Newspaper. 1932. Forty Years Ago in Saratoga. (From Saratoga Sun and Platte Valley Lyre August 25, 1982)

11 Saratoga Sun Newspaper. 1933. Forty Years Ago in Saratoga (From Saratoga Sun and Platte Valley Lyre October 26, 1893)

12 Saratoga Sun Newspaper. 1934. Forty Years Ago in Saratoga. (From Saratoga Sun and Platte Valley Lyre August 30, 1894)

13 Blackhall, J. 1909. Report for the Forest Atlas (Hayden National Forest) Medicine Bow Collection

14 Saratoga Sun Newspaper. 1934. Forty Yeara Ago in Saratoga. (From Saratoga Sun and Platte Valley Lyre. Feb. 15, 1894)

15 Coughlin, L.E. 1955. Statement prepared for Medicine Bow National Forest Historical Files. Medicine Bow collection

16 Nelson, J.W. 1907. Letter to District Forester from Forest Supervisor regarding estimate of board feet of timber on the Medicine Bow National Forest. Medicine Bow Collection

17 Jardine, J.T. 1911. Report of Service Studies - Grazing Hayden National Forest, Wyoming. Medicine Bow Collection

18 Douglas, L.A. 1912. Report based on range reconnaissance - Medicine Bow National Forest Medicine Bow Collection

19 Hayden National Forest. 1913. Preliminary Plan. Hayden National Forest Grazing Chapter. Medicine Bow Collection

20 Hayden National Forest. 1913. Contracts for marking timber. Carbon Timber Company. Medicine Bow Collection.

21 Medicine Bow National Forest. 1915. Letter to District Forester regarding history and growth of lumbering. Medicine Bow Collection

22 Medicine Bow National Forest. 1920. District 4 Report on Game and Fish. Medicine Bow Collection

23 Medicine Bow National Forest. 1921. Administrative Report - Grazing conditions favorable within the Medicine Bow National Forest. Medicine Bow Collection

24 Medicine Bow National Forest. 1921. Forest Office Notes. Medicine Bow Collection

25 Medicine Bow National Forest. 1921. District 4 Report on Game and Fish. Medicine Bow Collection

26 Author Unknown. 1924. The West Grows Wilder. Medicine Bow Collection

27 Coughlin, L.E. 1952. Medicine Bow Forest to Advertise 83 million board feet of timber for sale. News Release. Medicine Bow Collection

28 Medicine Bow National Forest. 1927. Kaibab deer shipped to Medicine Bow forest. Report for the Service Bulletin, Washington D.C. Medicine Bow Collection

29 Medicine Bow National Forest. 1925. Bulletin - Mountain lions destroy deer. Medicine Bow Collection

30 Medicine Bow National Forest. 1928. Annual Report for Bow District - Fish and Game. Medicine Bow Collection

31 Hilton, H.C. 1930. Memorandum for Forest Officers regarding insect control. Medicine Bow Collection

32 Hilton, H.C. 1931. Range Management Plans - Medicine Bow National Forest Medicine Bow Collection

33 Medicine Bow National Forest. 1933. Annual Fish and Game Report - Brush Creek District. Medicine Bow Collection

34 Medicine Bow National Forest. 1935. Annual Fish and Game Report - Brush Creek District. Medicine Bow

Collection

35 Medicine Bow National Forest 1936. Fish and Game Statistics - Brush Creek District Medicine Bow Collection

36 Medicine Bow National Forest. 1938. Annual Wildlife Report Medicine Bow National Forest Medicine Bow collection

37 Medicine Bow National Forest. 1938. Memorandum on beaver transplanting by L.E. Coughlin. Medicine Bow Collection

38 Medicine Bow National Forest. 1940. Annual Report - General Wildlife Conditions. Medicine Bow Collection

39 Medicine Bow National Forest. 1942. Administrative study on brushing in in skid trails. Medicine Bow Collection

44 Wood, D.R. 1995. Historic background for the Albany/Morgan Land Exchange Cultural Inventory Report - History of the the L, HP & P railroad. Unpublished report Medicine Bow National Forest Laramie, WY

APPENDIX 20

OCCURRENCE OF TECS SPECIES BY BIODIVERSITY AREA

Tables AP20.1 - AP20.4 contain summaries of observation records from the Wyoming Game and Fish and the Wyoming Natural Diversity databases. Observation records in both databases contain a variety of "sighting" information which ranges from well-documented observations, to records of calls or tracks but no actual sighting that can be considered completely reliable.

The number of records are shown for each Biodiversity Area as a function of time period (since 1985, before 1985 or no date). In order to be included on these list, records had to have a location precise to at least a Section (square mile). Records were counted for locations within the Forest Boundary or within a mile outside of the boundary. For fisher, wolverine, lynx and spotted bat, there is question as to the validity of the data. These data were compiled prior to the inception of Region 2 **FINE FILTER ASSESSEMENT** procedures in summer, 1994, so results may differ from the Nature Conservancy Report (Mills, 1995).

Table AP20.1 Records of TES sightings 1985-1995, by Biodiversity Area.

FEDERALLY THREATENED OR ENDANGERED SPECIES

BIODIVERSITY AREA	AMPHIBIANS		REPTILES		BIRDS		MAMMALS	
	spec	sight	spec	sight	spec	sight	spec	sight
SIERRA MADRE								
Northwest	0		0		1	2	0	
Southwest	0		0		1	1	0	
Encampment R.	0		0		1	4	0	
Southeast	0		0		1	1	0	
SNOWY RANGE								
Northwest	0		0		1	5	0	
Northeast	0		0		1	12	0	
NE Central	0		0		2	1	0	
Wilderness	0		0		1	3	0	
South Central	0		0		1	2	0	
Southeast	0		0		1	3	0	
SHERMAN MOUNTAINS								
	0		0		1	1	0	
LARAMIE MOUNTAINS								
Northwestern	0		0		1	1	0	
North Central	0		0		1	5	0	
South Central	0		0		0		0	
Southwestern	0		0		0		0	
Southern	0		0		1	4	0	

spec means number of species seen
sight means number of sightings for all species seen

Table AP20.1 continued

REGION 2 SENSITIVE SPECIES

BIODIVERSITY AREA	AMPHIBIANS spec	AMPHIBIANS sight	REPTILES spec	REPTILES sight	BIRDS spec	BIRDS sight	MAMMALS spec	MAMMALS sight
SIERRA MADRE								
Northwest	2	1	0		20	13	4	3
					15	4		
Southwest	0		0		5	1	4	11
					6	4		
					15	2		
					20	18		
Encampment R.	0		0		15	1	2	1
							4	7
Southeast	0		0		15	1	0	
					20	1		
SNOWY RANGE								
Northwest	0		0		4	1	1	1
					15	26	4	1
					18	1		
					20	4		
Northeast	3	13	0		15	8	3	1
					18	19	4	12
					20	2		
NE Central	1	1	0		4	2	0	
	3	5			7	3		
					15	2		
Wilderness	0		0		8	1	0	
					15	4		
South Central	0		0		7	1	0	
					15	2		
					18	4		
Southeast	1	2	0		3	1	0	
	3	6			14	1		
					18	2		
SHERMAN MOUNTAINS								
	0		0		15	4	0	
LARAMIE MOUNTAINS								
Northwestern	0		0		12	1	0	
					13	1		
					15	4		
North Central	0		1	1	12	1	0	
					15	1		
South Central	0		0		9	1	0	
					12	3		
					18	2		
Southwestern	0		0		15	1	0	
Southern	0		0		0		0	

Table AP20.2. Records of TES sightings prior t0 1985, by Biodiversity Area.

	FEDERALLY THREATENED OR ENDANGERED SPECIES					
BIODIVERSITY AREA	AMPHIBIANS		REPTILES		BIRDS		MAMMALS	
	spec	sight	spec	sight	spec	sight	spec	sight
SIERRA MADRE								
Northwest	0		0		0		0	
Southwest	0		0		0		0	
Encampment R.	0		0		0		0	
Southeast	0		0		0		0	
SNOWY RANGE								
Northwest	0		0		1	3	0	
Northeast	0		0		1	4	0	
NE Central	0		0		1	1	0	
					2	1		
Wilderness	0		0		1	7	0	
South Central								
Southeast								
SHERMAN MOUNTAINS								
	0		0		1	2	0	
LARAMIE MOUNTAINS								
Northwestern	0		0		0		0	
North Central	0		0		0		0	
South Central	0		0		1	2	0	
Southwestern	0		0		0		0	
Southern	0		0		0		0	

Table AP20.2 continued

	REGION 2 SENSITIVE SPECIES							
BIODIVERSITY AREA	AMPHIBIANS		REPTILES		BIRDS		MAMMALS	
	spec	sight	spec	sight	spec	sight	spec	sight
SIERRA MADRE								
Northwest	0		0		17	1	4	6
					20	5		
Southwest	1	2	0		10	1	4	1
					20	17		
Encampment R.	0		0		6	1	4	2
Southeast	0		0		20	1	2	1
							4	1
SNOWY RANGE								
Northwest	1	1	0		8	2	2	1
					11	1	4	2
					15	5	8	1
Northeast	1	1	0		15	6	3	3
	3	1			18	9	4	3
NE Central	1	4	0		4	3	4	1
	3	4			8	1		
					15	1		
Wilderness	1	7	0		8	3	2	1
	3	8			14	1	4	6
					15	13	8	1
					18	1		
					19	1		
South Central	No records?							
Southeast	No records?							
SHERMAN MOUNTAINS								
	1	1	0		8	1	5	1
					12	1		
					15	1		
LARAMIE MOUNTAINS								
Northwestern	0		0		15	1	0	
North Central	0		0		12	1	0	
South Central	0		0		12	7	0	
					19	2		
					18	2		
Southwestern	0		0		12	2	0	
Southern	0		0		12	2	0	

Table AP20.3 Records of TES sightings with no date.

FEDERALLY THREATENED OR ENDANGERED SPECIES

BIODIVERSITY AREA	AMPHIBIANS		REPTILES		BIRDS		MAMMALS	
	spec	sight	spec	sight	spec	sight	spec	sight
SIERRA MADRE								
Northwest	0		0		0		0	
Southwest	0		0		0		0	
Encampment R.	0		0		0		0	
Southeast	0		0		0		0	
SNOWY RANGE								
Northwest	0		0		0		0	
Northeast	0		0		0		0	
NE Central	0		0		0		0	
Wilderness	0		0		0		0	
South Central	0		0		2	3	0	
Southeast	0		0		0		0	
SHERMAN MOUNTAINS	0		0		0		0	
LARAMIE MOUNTAINS								
Northwestern	0		0		0		0	
North Central	0		0		0		0	
South Central	0		0		0		0	
Southwestern	0		0		0		0	
Southern	0		0		0		0	

Table AP20.3 continued

REGION 2 SENSITIVE SPECIES

BIODIVERSITY AREA	AMPHIBIANS		REPTILES		BIRDS		MAMMALS	
	spec	sight	spec	sight	spec	sight		
SIERRA MADRE								
Northwest	1	1	0		0		0	
Southwest	0		0		0		0	
Encampment R.	0		0		4	8	0	
Southeast	1	1	0		4	1	0	
SNOWY RANGE								
Northwest	1	1	0		0		0	
	3	1						
Northeast	1	2	0		0		2	1
NE Central	3	3	0		15	1	1	2
							2	1
							6	2
Wilderness	0		0		14	1	0	
South Central	0		0		15	1	4	2
Southeast	3	1	0		0		0	
SHERMAN MOUNTAINS								
	0		0		0		0	
LARAMIE MOUNTAINS								
Northwestern	0		0		0		0	
North Central	0		0		21	1	0	
South Central	0		0		0		0	
Southwestern	0		0		0		0	
Southern	0		0		0		0	

Table AP20.4 TES Data Summary by Biodiversity Area and time period

	#S	AMPHIBIANS	#S	REPTILES	#S	BIRDS	#S	MAMMALS
SIERRA MADRE								
Northwest								
1985+	1	tiger salamander			2	bald eagle	3	marten
					13	sandhill cranes		
					4	northern goshawks		
1985-					1	olive-sided flycatcher	6	marten
					5	sandhill cranes		
No date	1	boreal toad						
Southwest								
1985+					1	bald eagle	11	marten
					1	burrowing owl		
					4	Columbian sharp-tailed grouse		
					2	northern goshawks		
					18	sandhill cranes		
1985-	2	boreal toad			1	fox sparrow	1	marten
					17	sandhill cranes		
No date								
Encampment R.								
1985+					4	bald eagles	1	fisher
					1	northern goshawk	7	marten
1985-					1	Columbian sharp-tailed grouse	2	marten
No date					8	boreal owl		
					1	northern three-toed woodpecker		

Table AP20.4 Continued

SIERRA MADRE	#S	AMPHIBIANS	#S	REPTILES	#S	BIRDS	#S	MAMMALS
Southeast								
1985+					1	bald eagle		
					1	northern goshawk		
					1	sandhill crane		
1985-					1	sandhill crane	1	fisher
							2	marten
No date	1	boreal toad			1	boreal owl		
SNOWY RANGE								
Northwest								
1985+					5	bald eagle	1	dwarf shrew
					1	boreal owl	14	marten
					26	northern goshawk		
					1	osprey		
					4	sandhill crane		
1985-	1	boreal toad			3	bald eagle	1	fisher
					2	ferruginous hawk	2	marten
					1	golden-crowned kinglet	1	wolverine
					5	northern goshawk		
No date	1	boreal toad						
	1	wood frog						

	#S	AMPHIBIANS	#S	REPTILES	#S	BIRDS	#S	MAMMALS
SNOWY RANGE								
Northeast								
1985+	13	wood frog			12	bald eagle	1	lynx
					8	northern goshawk	12	marten
					19	osprey		
					2	sandhill crane		
1985-	1	boreal toad			4	bald eagle	3	lynx
	13	wood frog			6	northern goshawk	3	marten
					9	osprey		
No date	2	boreal toad					1	fisher
	1	wood frog						

Table AP20.4 continued

NE Central						
1985+	1	boreal toad	1	peregrine falcon	2	marten
	5	wood frog	2	boreal owl		
			3	common loon		
			3	northern goshawk		
1985-	4	boreal toad	1	bald eagle	1	marten
	4	wood frog	1	peregrine falcon		
			3	boreal owl		
			1	ferruginous hawk		
			1	northern goshawk		
No date	3	wood frog	1	northern goshawk	2	dwarf shrew
					1	fisher
					2	pygmy shrw
SNOWY RANGE						
Wilderness						
1985+			3	bald eagle		
			1	ferruginous hawk		
			4	northern goshawk		
1985-	7	boreal toad	7	bald eagle	1	fisher
	8	wood frog	3	ferruginous hawk	6	marten
			1	merlin	1	wolverine
			13	northern goshawk		
			3	osprey		
			1	pygmy nuthatch		
No date			1	merlin		
South Central						
1985+			2	bald eagle	2	fisher
			1	common loon	1	marten
			2	northern goshawk	1	ringtail
			4	osprey	2	fisher
					1	wolverine
1985-						
No date			3	peregrine falcon	2	marten
			1	northern goshawk		

Table AP20.4 continued

	#S	AMPHIBIANS	#S	REPTILES	#S	BIRDS	#S	MAMMALS
SNOWY RANGE								
Southeast								
1985+	2	boreal toad			3	bald eagle		
	6	wood frog			1	black swift		
					1	merlin		
					2	osprey		
1985-								
No date	1	wood frog						
SHERMAN MOUNTAINS								
1985+					1	bald eagle		
					4	northern goshawk		
1985-	1	boreal toad			2	bald eagle	1	Prebles J. mouse
					1	ferruginous hawk		
					1	northern goshawk		
					1	Lewis' woodpecker		
No date								

	#S	AMPHIBIANS	#S	REPTILES	#S	BIRDS	#S	MAMMALS
LARAMIE MOUNTAINS								
Northwestern								
1985+					1	bald eagle		
					1	Lewis' woodpecker		
					1	loggerhead shrike		
					4	northern goshawk		
1985-					1	northern goshawk		

Table AP20.4 concluded

	#S	AMPHIBIANS	#S	REPTILES	#S	BIRDS	#S	MAMMALS
LARAMIE MOUNTAINS								
North Central								
1985+			1	pale milk snake	5	bald eagle		
					1	Lewis' woodpecker		
					1	northern goshawk		
1985-					1	Lewis' woodpecker		
No date							1	spotted bat
South Central								
1985+					1	flammulated owl		
					3	Lewis' woodpecker		
					2	osprey		
1985-					2	bald eagle		
					7	Lewis' woodpecker		
					2	pygmy nuthatch		
Southwestern								
1985+					1	northern goshawk		
1985-					2	Lewis' woodpecker		
Southern								
1985+					4	bald eagle		
1985-					2	Lewis' woodpecker		

APPENDIX 21

* from DRAFT Ecosystem Management Glossary, May, 1994. Region 6 Ecosystem Management Implementation Team, Regional Office (R6) and Pacific Northwest Research Station, Portland, OR.

GLOSSARY OF TERMS

allochthonous	Obtaining energy and materials from outside the ecosystem.
allopatry	Pertaining to species that occur in different but often adjacent areas.
Altithermal	Period of high temperatures after the Pleistocene. Also called the Thermal Maximum approximately 4000-7000 YBP (years before present).
bathometric	A map showing isolines of lake depth.
benthic	Bottom-dwelling aquatic organisms.
community*	An assemblage of species at a particular time and place.
connectivity*	Condition in which the spatial arrangement of land cover types allows organisms and ecological processes (such as disturbance) to move across the landscape. Connectivity is the opposite of fragmentation.
connectivity (landscape)*	The spatial contiguity within the landscape; a measure of how easy or difficult it is for organisms to move through the landscape without crossing habitat barriers.
conservation*	The use and management of natural resources according to principles that assure their sustained economic and/or social benefits without impairment of environmental quality.
conservation biology*	The science of biological scarcity and diversity.
conservation strategy*	A management plan for a species, group of species, or ecosystem that prescribes standards and guidelines that if implemented provide a high likelihood that the species, groups of species, or ecosystem, with its full complement of species and processes, will continue to exist well-distributed throughout a planning area, i.e., a viable population.

corridors*	The landscape elements that connect similar patches through a dissimilar matrix or aggregation of patches.
dendrochronology	The study of tree ring patterns in relation to time.
desired future condition*	A portrayal of the land or resource conditions which are expected to result if goals and objectives are fully achieved (draft 36 CRF 219).
dessication	Drying out of biomass causing damage or death.
diabase dikes	Intrusion of basaltic rock into other rock.
dispersal*	The movement, usually one way and on any time scale, of plants or animals from their point of origin to another location where they subsequently produce offspring.
disturbance*	A discrete event, either natural or human induced, that causes a change in the existing condition of an ecological system.
diversity*	The distribution and abundance of plant and animal species and communities in an area (26 CFR 219).
ecology*	The science of the interrelationships between organisms and their environments.
ecological aproach*	The approach to natural resource management that follows the principles as described in the paper, "An Ecological Approach to Management - A framework for National Guidance."
ecological pocesses*	The actions or events that link organisms and their environment, such as predation, mutualism, successional development, nutrient cycling, carbon sequestration, primary productivity, and decay .
Ecoregion*	A continuous geographic area in which the environmental complex, produced by climate, topography, and soil, is sufficiently uniform to develop characteristics of potential major vegetation communities.
ecosystem*	The system formed by the interaction of a group of organisms and their environment.

ecosystem health*	The state of an ecosystem in which processes and functions are adequate to maintain diversity of biotic communities commensurate with those initially found there.
ecosystem management*	The skillful, integrated use of ecological knowledge at various scales to produce desired resource values, products, services and conditions in ways that also sustain the diversity and productivity of ecosystems.
ecosystem pattern*	The structure that results from the distribution of organisms in, and their interaction with their environment. Includes zonation, stratification, activity or periodicity, food-webs, reproductive, social and stochastic.
ecosystem structure*	The physical arrangement of the various components.
ecosystem sustainability*	The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resource uses, products, or services from an ecosystem while maintaining the integrity of the ecosystem over time.
edaphic	Soil factors.
edaphic climax*	A climax determined largely by the nature of the soil conditions.
endemic*	(n. Endemism) Restricted to a specified region or locality.
epidemic	A high incidence of infestation or infection.
exotic species*	Species which occur in a given place, area, or region as the result of direct or indirect, deliberate or accidental introduction of the species by humans, and for which introduction has permitted the species to cross a natural barrier to dispersal.
extinct*	No longer existing.
extirpation*	The elimination of a species from a particular area.
fire regime*	The characteristic frequency, extent, intensity, severity, and seasonality of fires in an ecosystem.

forest canopy*	The cover of branches and foliage formed collectively by tree crowns.
forest type*	A category or class of forest defined by its vegetation (species composition) and/or locality.
fragmentation*	Breaking up of contiguous areas into progressively smaller patches of increasing degrees of isolation.
function*	The flow of mineral nutrients, water, energy, or species.
gap phase succession*	Progressive changes in community structure, composition, and diversity following small-scale forest disturbances.
geographic information system*	(GIS) A spatial type of information management system which provides for the entry, storage, manipulation, retrieval, and display of spatially oriented data.
glacial erratic	Large scattered rocks distributed by glaciers or glacial meltwater.
gradient	A gradual change of an environmental factor across an area, i.e. climatic gradient, elevation gradient, moisture gradient.
habitat connections*	A network of habitat patches linked by areas of like habitat. The linkages connect habitat areas within the watershed to each other and to areas outside the watershed. These connections include riparian areas, mid-slopes, and ridges. In the case of old-growth forest habitat connections, each connection is planned to be sufficiently wide (at least 1,000 feet) to retain interior old-growth associated species.
Holocene	The most recent geological Period (since the Pleisticene).
indicator species*	Species that indicate the presence of certain environmental conditions, seral stages, or previous treatment. One or more plant species selected to indicate a certain level of grazing use.
indigeneous	Native to an area.
juxtaposition	The relative positions of patches in a matrix.

kettlehole	Bowl shaped depression from a large block of glacial ice.
kimberlite	A mineral which may contain diamonds.
landscape*	Large regional units of land that are viewed as a mosaic of communities irrespective of political or other artificial boundaries.
landscape ecology*	The study of spatial and temporal interactions and exchanges across heterogeneous landscapes, the influences of spatial heterogeneity on biotic and abiotic process, and the management of spatial heterogeneity.
landscape edge*	The interface between landscape elements of different composition and structure, for example between an open clearcut and a closed-canopy forest.
landscape heterogeneity*	The variation in aggregations of landscape elements across a landscape.
landscape matrix*	The most concentrated portion of the landscape, that is, the vegetation type that is most contiguous.
landscape patches*	The areas of vegetation that are relatively homogeneous internally (with respect to composition, successional stage, etc.) and that differ from what surrounds them (the matrix, or other patches).
landscape patchiness*	The density of all types of patches within a landscape; considers the diversity among patches.
linkages*	Route that permits movement of individual plant (by dispersal) and animals from a landscape unit and/or habitat type to another similar landscape unit and/or habitat type.
macroinvertebrate	Any large (macroscopic) invertebrate organism (examples: beetles, fly larvae, snails)
mafic	An igneous rock rich in magnesium and iron and low in silica.
matrix*	The most extensive and most connected landscape element type present which plays the dominant role in landscape functioning. Also, a landscape element surrounding a patch.

mature forest*	Generally used in an economic sense to indicate that a forest has attained harvest age.
metaconglomerate	Metamorphosed conglomerates.
metagreywacke	Metamorphosed clayey sandstones with a high feldspar content.
metasediments	Metamorphosed sediments.
microclimate*	The climatic condition of a small area resulting from the modification of the general climatic conditions by local differences in elevation or exposure; the sequence of atmospheric changes within a very small region.
montane	An elevation zone from approximately 6000-8000 feet in Wyoming, between the foothills and subalpine zones.
moraine	A pile of debris left along the edges, at the end of, or beneath a glacier.
multivariate analysis	A statistical analysis technique where many variables are analyzed simultaneously.
mycorrhizae	Fungi which associate symbiotically with plant roots.
natural variability*	Range of the spatial, structural, compositional, and temporal characteristics of ecosystem elements during a period specified to represent "natural" conditions.
new perspectives*	A Forest Service project to bring about new thinking, new technologies, and new alliances to improve ecological management of the National Forest System. Managing ecosystems to sustain their diversity and productivity for resource uses, values, products, and services people need and want for the future is the major focus of New Perspectives.
nunatak	An ice-free area above a glacier, usually a mountain-top.
nutrient cycling*	Circulation or exchange of elements such as nitrogen and carbon between non-living and living portions of the environment. Includes all mineral and nutrient cycles involving mammals and vegetation.
obligate species*	A plant or animal that occurs only in a narrowly defined habitat such as tree cavity, rock cave, or wet meadow.

oligotrophic	A body of water with low biotic productivity.
ordination	A statistical analysis technique which separates dissimilar groups, displaying them on a two-dimensional graph in order of their dissimilarity. Often used to array plant communities along gradients.
paleosol	A buried soil formed during an interglacial period.
patch*	Ecosystem elements (e.g., areas of vegetation) that are relatively homogeneous internally and that differ from what surrounds them.
pattern*	The spatial arrangement of landscape elements (patches, corridors, matrix) which determines the function of a landscape as an ecological system.
piscivorous	fish-eating
planimetric	Pertaining to areal measurements made using a planimeter. These are used to estimate acreages by measuring the perimeter of a polygon on paper.
plant association*	Stands of vegetation with similar combinations of species united into abstract types; a basic unit in plant community classification.
Pleistocene	The second epoch of the Quaternary Period, also called the Ice Ages, approximately 2,000,000-18,000 YPB.
population*	A group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group.
population viability*	Probability that a population will persist for a specified period across its range despite normal fluctuations in population and environmental conditions.
potential natural community*	The vegetation that would become established in an area in the absence of man under present climatic and site conditions but without an assumption that it was a return to climax conditions existing prior to human disturbance.
potential vegetation*	Vegetation that would develop if all successional sequences were completed under present site conditions (e.g., habitat type).

principal components analysis	A statistical technique similar to ordination used to find the major trends in complex data with many variables
Quaternary	The later of the two periods of the Cenozoic Era (Tertiary and Quaternary). Contains the Pleistocene and Holocene Epochs, approximately 2,000,000 - present.
range of variability*	The spectrum of conditions possible in ecosystem composition, structure, and function considering both temporal and spatial factors.
refugia*	Locations and habitats that support populations of organisms that are limited to small fragments of their previous geographic range (i.e., endemic populations).
relict*	A remnant or fragment of the plant community that remains from a former period when it was more widely distributed.
resilience*	The ability of an ecosystem to maintain diversity, integrity and ecological processes following disturbance.
restoration*	The study of recreating entire communities of organisms closely modeled after communities that occur naturally.
riparian ecosystem*	Those assemblages of plants, animals, and aquatic communities whose presence can be either directly or indirectly attributed to factors that are water-influenced or related. Interacting system between aquatic and terrestrial situations, identified by soil characteristics, and distinctive vegetation that requires or tolerates free or unbound water.
RIS	Resource Information Data base. The official Forest Service database in Region 2 USFS.
seral*	Refers to species or communities that are eventually replaced by other species or communities within a sere.
species richness*	A component of community species diversity that is expressed by simple ratios between total number of species.
succession*	A process of community development that involves changes in species and community processes over time.

sustainability*	The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resource uses, products, or services from an ecosystem while maintaining the integrity of the ecosystem over time.
sympatry	Pertaining to closely related species that occur in the same area.
talus	Fallen material which accumulates at the base of a steep slope.
Tertiary	The earlier of the two periods of the Cenozic Era (Tertiay and Quaternary). Contains the Paleocene, Eocene, Oligocene, Miocene, and Pliocene Epochs, approximately 65,000-2,000,000 YBP.
unconformity	A surface of erosion or non-deposition that separates older and younger rocks.
vascular plant	Plants with xylem to conduct water and phloem to conduct nutrients.
viability*	The likelihood of continued existence in an area for some specified period of time.

INDEX

aerial photographs . . . . . 5-46 to 5-53
alpine ecosystems . . . . . 5-19, 5-20, 6-3 to 6-6
American bittern 8-45
animal species . . . . . 8-1 to 8-12, apndx 9, **AP9-3, AP9-4**
aquatic ecosystems . . . . . 7-20 to 7-32, 8-2 to 8-6
Arizona monsoon 3-9, 3-10, 4-8
archaeology 4-1, 4-8
aspen ecosystems 5-25, 6-70, 6-71, **6-148**, 8-7
autumn willow 8-19
Baird's sparrow 8-46
bald eagle 8-46
bears . . . . . 8-92 to 8-94, **8-94**
beavers 4-24, 4-36, 4-38, 4-40
big game . . . . . 8-87 to 8-91, **8-112**, **8-117**, **8-122**, **8-125**
big game population estimates . . . . . **8-88**, **8-90**, 8-88 to 8-91
biological diversity (defined) 1-1, **1-2, 2-2**
biological diversity (issues) 1-4, 1-10
biological diversity (strategies) 1-10, 1-20
black swift 8-47
black tern 8-48
blowdown 6-43
boreal owl 8-49
boreal toad 8-33, **8-108**
burrowing owl 8-51
classification **3-4, 8-4**
clear cuts (succession in) . . . . . 6-66 to 6-68, apndx 16
clear cutting . . . . . 6-45 to 6-49, 6-63 to 6-68, apndx 16
AP16-16, AP1-17, AP16-21, AP16-22
AP16-26, AP16-27, AP16-28, AP16-29
AP16-30, AP16-31, AP16-32

climate . . . . . 3-8 to 3-12, **3-11, 3-24, 3-25, apndx 3 AP3-5, AP3-6, AP3-7, AP3-8 AP3-10, AP3-11, AP3-15, AP3-16**
climate change 3-13, **4-6**
climate modification 3-13
climate reconstruction 4-6, 4-7
clustered lady's slipper 8-19
Colorado River cutthroat trout . . . . . 8-1, 8-22 to 8-32, **8-26, 8-108**
Colorado Tansy aster 8-20
Columbian sharp-tailed grouse 8-51
comandra blister rust 6-12
common land unit 3-2
common loon 8-52
conservation biology 1-19, 1-20
coarse filter 1-15, 2-1, 2-2
cover types 6-2
diseases (forest) 6-10, 6-12, 6-38
disturbance (terrestrial) . . . . . 4-22, 5-31, 5-32, 6-43, **6-56, 6-135** apndx 12
disturbance (aquatic, riparian) 7-4, **7-5**, 7-6, 7-39
Douglas fir 6-22
dwarf mistletoe . . . . . 6-12 to 6-16, **6-14, 6-110**
dwarf shrew 8-38
dredging (of streams) 4-22
earthquakes 3-7, **3-8**
eastern short-horned lizard 8-37
ecological assessment 1-6
ecological continuity 6-70
ecological integrity 1-1, 1-20

ecological sections 3-2, **3-4**
ecological subsections . . . . . 3-2, **3-5**, 3-6, **3-21**, apndx 18
ECOMAP 3-2, **3-4**,apndx 18
ecosystem functions 2-6
ecosystem management 1-6, 1-11, 1-17, 1-18
ecosystem processes 2-6
exotic plant species . . . . . apndx 5
El Nino 3-10, **3-11**
ferruginous hawk 8-53
fine filter 1-15, 2-1
fire . . . . . 4-8, 4-9, 4-16, 4-17, 6-23 to 6-28, **6-31**, 6-30 to 6-35, **6-114, 6-118, 6-119, apndx 15, AP15-16, AP15-17, AP15-18 AP15-19, AP15-21, AP15-22, AP15-23, AP15-24, AP15-25 AP15-26, AP15-27, AP15-28, AP15-29, AP15-30, AP15-51 AP15-52, AP15-33, AP15-34**
fire (historical accounts) . . . . . 4-13 to 4-15, 4-28 to 4-33, 6-34, apndx 15
fish (indigenous) . . . . . 7-2, 7-32 to 7-34, **7-33**
fish introductions . . . . . 4-24 to 4-26, **4-25**, 4-36, 4-37, 7-2, **7-35**
flammulated owl 8-54
forest age continuity 6-70
forests . . . . . **6-102**, **6-105**, **6-106**, **6-108, apndx 11 AP11-16, AP11-19**
fox sparrow 8-55
fragmentation . . . . . 2-4, 2-5, 6-55 to 6-57
fringe-tailed myotis 8-39
fungi . . . . . apndx 8, **AP8-4**
geology 3-3, 3-6, 3-7, **3-32**, **3-33**
geomorphology 3-3
glaciers 4-4, 4-5

GLEES 6-7
glossary . . . . . apndx 21
golden-growned kinglet 8-56
grasslands 6-71, 8-6
heavy metal pollution 4-23
historic accounts . . . . . 4-10, 4-11, 4-28 to 4-34, **4-54**, **4-55**, **4-56**
apndx 19, AP10-2, AP19-3, AP19-4, AP19-7, AP19-11
historical forest . . . . . 6-29 to 6-35
historical photographs . . . . . 5-36 to 5-39
horizontal diversity 2-6
hydraulic mining 4-22
hydrology . . . . . 6-39 to 6-42, **6-125**
ice age 4-3
integrated resources inventory (IRI) 3-2
invertebrate 2-5, **7-27, 8-4**
krummholz . . . . . 5-19, 5-35, 6-4 to 6-6
La Nina 3-10, 3-11
land classification 3-2, **3-4, 3-18, 6-91, AP2-3, AP2-3, AP2-4, AP2-21**
landslides . . . . . 3-7, apndx 14, **AP14-10**
landtype (landtype association) 3-2, **3-4**, **3-5**
landscape diversity . . . . . 5-1 to 5-35
landscape ecology 1-20
landscape metrics . . . . . 2-3, 6-58 to 6-63, **6-147,** apndx 11
AP11-3, AP11-9, apndx 17, **AP17-4, AP17-5, AP17-6**
Laramie columbine 5-30, 8-21
law 1-6, **1-8**, 1-9, 1-17, 1-19
Lewis' woodpecker 8-57
lichens . . . . . 6-68 to 6-70, apndx 7, **AP7-15, AP7-17, AP7-18**, apndx 16
limber pine 6-22

livestock use (historic) 4-18, 4-27, 4-33, 4-34, **4-34**
lodgepole pine ecosystems 5-22, 5-24, 6-7, 6-23, **6-120**, 6-123, 8-7
loggerhead shrike 8-58
long-billed curlew 8-58
long-eared myotis 8-40
long-legged myotis 8-41
major ecosystems . . . . . 5-1 to 5-35
marten 8-43
mean fire return interval **6-27**
merlin 8-59
mountain lion . . . . . 8-92 to 8-94, **8-94**
mountain pine beetle . . . . . 6-17 to 6-19, **6-20**, 6-21
mountain plover 8-60
mountain ranges (of MBNF) . . . . . 3-1, 3-3, 3-6, 5-19 to 5-28
neotropical migratory birds . . . . . 8-71 to 8-86, **8-79**, **8-82**, **8-84** apndx 10
northern goshawk . . . . . 8-60 to 8-64
northern leopard frog 8-36
northern three-toed woodpecker 8-64
nutrient cycling 6-42
old growth . . . . . 1-10, **6-137**, 9-19 to 9-32, **9-24**, **9-25**, **9-26**
9-41, 9-43, 9-45, 9-47, 9-49, 9-51. 9-53, 9-55
olive-sided woodpecker 8-65
osprey 8-66
pale milk snake 8-37
paleoclimate 4-2
paleoecology 4-2
paleosols 4-5
palynology 4-5

partial cutting . . . . . 6-45 to 6-49
peregrine falcon 8-67
plant species . . . . . 8-8, 8-10, 8-11, 8-19, 8-22, apndx 4
AP4-5, AP4-5, AP4-6, apndx 5, **AP5-3, AP5-5**
Pleistocene . . . . . 4-3 to 4-5
policy . . . . . 1-9 to 1-16
ponderosa pine ecosystems . . . . . 5-26 to 5-30, 6-19, 6-39, **6-117, 6-124**
population viability 2-4, 2-5
principal components analysis . . . . . 6-60 to 6-62
purple martin 8-68
pygmy nuthatch 8-69
pygmy shrew 8-38
range of natural variability 1-5, 1-15, 2-3, 4-1, 4-2
6-62 to 6-66, 6-145
range of natural variablity (fire) . . . . . 6-31, 6-33 to 6-35
recreation 4-43
regeneration 6-49, 6-50, **6-129**
research natural areas . . . . . 9-10 to 9-18, **9-12, 9-13, 9-14, 9-15, 9-38**
reservoirs 4-41, 4-42
ribbon forest . . . . . 6-4 to 6-6
riparian ecoystems 5-22, 5-23, 5-25, 5-27
5-30, 7-2, 7-3, 7-36 to 7-47
7-37, 7-39, 7-40, 7-41, 7-55
riparian condition . . . . . 4-10, 4-40 to 4-42, **7-5**
roadless areas 9-3 to 9-9, **9-5, 9-7, 9-37**
roads 4-43
Rocky Mountain juniper 6-22
roller chopping 6-45
sandhill crane 8-69

scale . . . . . 2-2 to 2-6
sensitive species (Region 2) 8-11
serotiny 6-11
sheep grazing . . . . . 6-6 to 6-7
shrublands 6-71
small-footed myotis 8-42
spruce forest . . . . . 5-21, 5-24, 6-7 to 6-10, 6-35 to 6-38
spruce-fir forest ecosystems 5-21, 5-24, **6-115**, **6-120**, 8-7
stand age . . . . . 4-10, 6-53, **6-116**, **6-130**, **6-132**, **9-45**, apndx 12
stand structure . . . . . 6-53, **6-133**, **9-47**, apndx 12
subalpine ecosystems 5-20, 5-21, 5-24
succession (forest) . . . . . 6-35 to 6-37, 6-72, **6-73, 6-114**
6-115, 6-121, 6-122, 6-123, 6-124
Thermal maximum 4-3
threatened, endangered, sensitive animal species . . . . . 8-8 to 8-17, 8-22 to 8-71
8-9, **8-10**, **8-11**
apndx 20, See lists page 8-18
AP20-1, AP20-3, AP20-5, AP20-7
threatened, endangered, sensitive plant species 8-1, 8-10, 8-11
8-9, **8-10**, **8-11**
threatened, endangered, sensitive bird species . . . . . 8-45 to 8-71
8-9, **8-10**, **8-11**
tie driving **4-20**
tiger salamamder 8-36
tie driving . . . . . 4-18 to 4-22, 4-38, **4-57**
tie hacking . . . . . 4-18 to 2-22
timber harvest . . . . . 4-38, 6-44 to 6-48, **6-47**, **6-48**, 6-50 to 6-52, **6-64**
6-126, **6-128, 6-138, 6-142, 6-146,** apndx 12,
AP12-3, AP12-7, AP12-18, AP12-29, AP12-31

Townsend's big-eared bat 8-43
upland sandpiper 8-70
vegetation classification . . . . . 6-3, 6-23, apndx 6, **6-95**, **6-99 6-100**
6-101, **7-39**, 7-40, 7-41, **7-55**
9-14, 9-15, 9-36, apndx 6, **AP6-4**
vegetation diversity 6-2, 6-3
vertical diversity 2-6
water diversions (transcontinental) . . . . . 4-24, 4-41, 4-42, 6-39 to 6-42
water quality 4-23
water yield (snow catchment) 6-41, 6-126
watersheds (defined) . . . . . 7-13, apndx 2, **AP2-9**
watersheds (described) . . . . . 7-13 to 7-20, apndx 13
watershed health . . . . . 4-41, 4-42, apndx 14
watershed values 4-36
watersheds of concern . . . . . **6-64**, 7-2, 7-7 to 7-12, **7-8, 7-53**
Weber's ipomopsis 8-21
western boreal toad 8-33
white-faced ibis 8-70
wilderness . . . . . **9-2**, 9-2 to 9-3, **9-5, 9-36**
wildlife extirpations 4-18, 4-34, 4-38, 4-39
wildlife habitat 6-51
wood frog 8-35, **8-111**

United States Department of Agriculture	Forest Service	Rocky Mountain Region	Medicine Bow-Routt National Forest

Reply to: 1920 Date: June 5, 1996

Subject: Biophysical and Historical Aspects of Species and Ecosystems of the Medicine Bow National Forest

To: Users of this Material

Attached is a compilation of information related to biophysical and historical aspects of species and ecosystems of the Medicine Bow National Forest. The package includes information revised as of May 1996 and various reviews of the material conducted prior to that time.

This is not the Biodiversity Assessment intended for use in the Medicine Bow Revised Forest Land and Resource Management Plan. This package does not contain the coarse filter, fine filter and range of natural variability information needed for a Biodiversity Assessment. Dee Hines of the Plan Revision IDT will take the lead in preparing the Biodiversity Assessment. Dee has a Masters Degree in Forest Ecology from Utah State Univ. and has recently completed all four modules of training offered by the Institute of Ecosystem Management. Contact Dee for more information on the Biodiversity Assessment.

This package includes current information gleaned from our data bases and provides a valuable list of research citations which may be relevant to various project level analysis efforts. **Opinions and suggestions are solely those of the authors.** Forest Policy is reflected in the Forest Plan and will be updated in the Forest Plan Revision effort. For example, the oldgrowth and patch linkage system discussion which begins on page 9-22 represents one possible way of dealing with this issue. The Forest Plan Revision will look at this recommendation and others before incorporating direction into the Forest Plan.

This information also highlights areas needing further study. For example, pages 6-66 through 6-70 discuss issues related to forest succession, site preparation and lichen biodiverity. The authors speculate on some causes and effects but admit that more study is needed.

I hope you find this information useful while keeping in mind the comments and concerns expressed by the professionals and scientists who reviewed it.

Jerry Schmidt

JERRY E. SCHMIDT
Forest Supervisor

cc Staff
District Rangers

United States Department of Agriculture	Forest Service	Rocky Mountain Region	Medicine Bow-Routt National Forest

Reply to: 1920 **Date:** April 26, 1996

Subject: Biodiversity Assessment

To: Judy Von Ahlefeldt

I have completed my evaluation of your project concerning biodiversity on the Medicine Bow National Forest. I have studied the reviews performed by the Regional Office (attached) and those done by the scientific and administrative committees.

Although some portions of your work will be useful, I find it unacceptable for use as a Biodiversity Assessment for the Medicine Bow Forest Plan Revision. Your work fails to characterize ecosystems and the biodiversity of those systems and does not evaluate the status of these systems in a sense useful to or relative to forest management operations. I appreciate your effort to compile information about the Medicine Bow National Forest. I am disappointed that the time, effort and money expended did not result in the assessment information needed for our Forest Plan Revision.

As we agreed last November, you should not work further on this project. I want you to give your electronic version to Dee Hines of the Plan Revision Team for his use in preparing a Biodiversity Assessment for the Forest Plan Revision.

Also Judy, it is critical that the Range of Natural Variability Report you are preparing for the Northern Great Plains meet the needs of that planning effort. As you know, you need to work closely with Dave Cawrse on the Planning Team in Chadron and Dan Uresk at the RM Forest and Range Experiment Station to ensure that your work meets needs and expectations according to the standards and timelines established for the Northern Great Plains assessment and planning process.

Jerry E. Schmidt

JERRY E. SCHMIDT
Forest Supervisor

cc Staff
Mary Peterson, Nebraska National Forest
Dave Cawrse, Nebraska National Forest
Dan Uresk, Rocky Mountain Forest and Range Experiment Station
Regional Forester

United States Department of Agriculture

Forest Service
Rocky Mountain Region

P.O. Box 25127
Lakewood, CO 80225-0127
Delivery: 740 Simms St.
Golden, CO 80401

RECEIVED
APR 1 1996
Medicine Bow

File Code: 1920

Date: MAR 28 1996

Subject: Biodiversity Assessment

To: Forest Supervisor, Medicine Bow/Routt NF

Staff specialists and scientists in our three areas of responsibility have reviewed the draft Biodiversity Assessment for the Medicine Bow National Forest. This letter conveys a summary evaluation of that work, discussion of risks the Forest Service would assume were we to accept this document, and a set of resulting recommendations we offer for your consideration.

Evaluation

Although a considerable amount of time and effort clearly has been devoted to development of this document, we conclude that it, for the most part, should not be used as the basis for a biological diversity assessment for the Forest Plan revision. A new assessment should be prepared which is more objective, focused on the Medicine Bow Forest and incorporates only the needed information for coarse filter, fine filter, and range of natural variation.

Assessments in general are done to:

Address certain issues from a larger context, which is more cost efficient.

Help comply with the many applicable environmental laws.

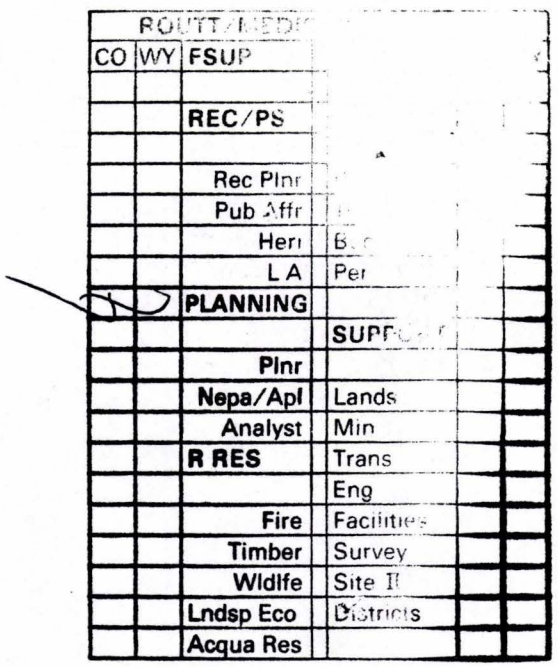
Provide improved resource integration.

Better look at broader resource topics such as widely distributed wildlife species.

Compile data for monitoring and evaluation, and

Determine historic and current resource conditions, capabilities and trends.

The principal purposes of an ecological assessment (including one which focuses on biodiversity) in the National Forest System are to characterize ecosystems and the biodiversity of these systems, and to evaluate the status of these systems in some sense useful to or relative to human management of them. The Medicine Bow Biodiversity Assessment provides a considerable amount of characterization of variable quality, but provides little analysis and almost no evaluation. It does not accomplish its stated objectives; it would provide a very weak and risky basis for subsequent management decision making. We are concerned about the quality of the reasoning displayed in some key chapters. We are significantly concerned about the unsupported assertions and conclusions made throughout the document.


ROUTT/MEDI
CO
WY
FSUP
REC/PS
Rec Plnr
Pub Affr
Herı
L A
Per
PLANNING
SUPP
Plnr
Nepa/Apl
Lands
Analyst
Min
R RES
Trans
Eng
Fire
Facilities
Timber
Survey
Wldlfe
Site I
Lndsp Eco
Districts
Acqua Res

A technical or scientific style of writing normally presents information, and then shows how conclusions can be reached directly from the descriptive information or reasoned from it. Scientists and technical authors generally try to write in such a way as to show the reader how and why these conclusions could be logically or reasonably reached. But this is not the style of this document. The document rarely contains any section-by-section reasoned assessment of biodiversity.

In the beginning, the document gives evidence of a reasonably well-structured conceptual framework with respect to the process of characterization. However, the discussion in Chapter 2 does not relate directly to the Medicine Bow National Forest, and as such, does not belong in a Biological Diversity Assessment.

The document begins characterization of the Medicine Bow National Forest with a description of some of the broad physical factors (climatic factors, temperature, moisture, solar insulation, elevation and aspect) which shape the environment. It contains some good information about climatic and other patterns across the landscape. The author has clearly worked hard to amass sources of information. This is an important beginning since it is these factors which shape the broad possibilities for lifeform and primary productivity, and which provide the initial basis for evaluation of biodiversity. Yet the document doesn't contain any particular observations or conclusions drawn from the data presented in this chapter.

In a particularly significant omission, there is no explicit statement that these mountains are highly variable with regard to environmental condition. The apparent high degree of variability (and the effective scale at which it may occur) of these mountains has enormous implications for the amount of biodiversity we would expect to find in this kind of physical environment. This observation should be the first critical point in our understanding and evaluation of the status of biodiversity in these mountains. Yet the relative amount of variation, especially at different scales, is never described or discussed, not even in contextual terms. Patterns of climatic factors are described only in a general manner. The reader must pay close attention to the maps contained in the rear of the chapter, and draw his or her own conclusions about the amount of variability and the implications for biodiversity.

The author understands that climatic patterns provide the first portion of the physical context for biodiversity and put what data they can here, but the document contains no reasoning nor conclusions from this data, no discussion of the implications for biodiversity, or for what we should expect. For example, do the descriptive data about climatic variables presented here coincide with the levels of the biotic processes of interest to us, or will we need to make reasonable inferences about the effect climatic patterns are likely to have on the nature of life? If we need to make reasonable inferences about the significance of these factors for the biodiversity of the area, which seems likely, what are these inferences?

Chapter 3 (the first chapter in the ecological portion of the document) describes important features of the Medicine Bow and contains a lengthy set of references for this description. But it lacks any discussion of the implications of these features for biodiversity, and even overlooks the most salient observation and implication: the fact of very high variability.

Succeeding chapters generally follow a similar pattern of initial characterization, but subsequent lack of discussion or reasoning from the descriptions, particularly with respect to the implications for biodiversity. The next chapters present characterizations of forest and aquatic systems, including riparian areas. The chapter on aquatic systems comes closest to what we would expect of basic ecological characterization and assessment, but the other chapters contain very broadly made characterizations. Maps in the rear of the chapters convey some area detail, but the text usually focuses on the highest, most general level of description.

The document makes a general assertion about the scales we should use in discussing biodiversity on page 2-7, but does not make explicit use of this framework in the document. It does not explain how the status of biodiversity at one scale is tied to biodiversity at other scales. Other Biological Diversity Assessments for Forest Plan revisions discuss in general terms, both the province and section level of the National Hierarchy.

The chapter on wildlife is not consistent with other assessments as well. The primary chapter here is mostly a collection of descriptions of faunae. Some potentially useful maps of species distribution are presented (again in the rear of the chapter), but these are not remarked upon to any depth at all. The collection of individual species descriptions are arranged in alphabetical order, not in any order associated with any sense of ecological functions, scale, or order of habitat affiliation, nor is an attempt made to describe any of these relationships. Biological Diversity Assessments should focus on rare species, not ones that are common.

The analysis of clear cutting/strip cutting patterns may be suspect because the factor analysis purports to indicate the amount of recent change in biodiversity by means of comparing properties of the managed areas of the Forest against properties of a very small number of reference areas (apparently Roadless Areas). No information is presented about the representativeness of these reference areas in comparison to the background amount of variability of the Forest, and in any case, the number of sample reference areas appears to be too small in relationship to the number of their properties (individual reference variables) being studied. (Several very fundamental errors of statistical reasoning seem to occur here. But, again, too little information is presented to accurately evaluate this analysis.)

With regard to the ecological science portions of the document, there are a number of opinions and unique assertions made as if they are scientific statements. For example, it does not seem to us that biological diversity can be assumed to be the same as biological integrity, as is done on page 2-2. This one particularly cuts to the point of an assessment - which seems to be to first determine the status of biological diversity, and then try to figure out what effect the current state of biodiversity has on biological integrity. Statements like ecosystem function is [the] cumulative property of ecosystem processes are the opinions of the authors - but asserted as if they are widely accepted scientific statements.

There are numerous items of a questionable nature which are not individually serious but taken as a whole, cause us to discount some of the material reported here. For example, some of the cited studies are used in an inappropriate manner. The snag studies referenced in Chapter 8 are out of date. These studies were made for Colorado's Front Range during a time when wood burning was a common occurrence. It's likely that these are not quite as applicable to the Medicine Bow today as they appear to be.

Similarly, the work by Crocker and Bedford is controversial: many researchers strongly disagree with the methods used and the findings claimed by these authors.

Policy

The executive summary contains far too much management direction which is not appropriate for an assessment. The assessment is the NFMA side of the analysis, and management direction needs to be addressed with NEPA analysis. Design of an old growth linkage system could have been identified as a management consideration (NFMA) but should not have been done as a part of the assessment. Such a consideration could be evaluated as some future date as an alternative in a NEPA analysis.

Chapter 1 contains large sections of text purporting to describe land and forest management policies of the USDA Forest Service, and the legislative basis for these policies. However, these sections do not describe USDA Forest Service policy accurately.

For example, on page 1-3, the document states that direction for management of biological diversity on Federal Lands [sic] comes from three sources: law, policy and precedent. The document then proceeds to list laws which supposedly provide legislative direction for conservation of biological diversity in the United States. Unfortunately, these are legally and technically incorrect: the named laws do not direct any agency of the federal government to conserve biological diversity. In fact, there are no references to conservation of biological diversity or even biological diversity in any of the cited laws and regulations.

In another example, the document appears to claim that it is USDA Forest Service policy to:

> maintain representation of native ecosystems across natural ranges (native diversity) (pg. 1-4), and
>
> maintain evolutionary and ecological processes for long-term ecosystem sustainability, (pg. 1-4)

The document also states that in the absence of new laws specifically directing conservation of biological diversity, national strategies to maintain biological diversity have been developed within the Department of Agriculture and the Department of Interior as agency policy (pg. 1-5), and Forest Service research has been a leader in formulating policy on biological diversity which has been subsequently been accepted by NFS management as Policy. This has been done via General Technical reports, (pg. 1-10).

The document also contains completely incorrect statements such as the [Forest Service] policy of cutting the oldest stands first, (Executive Summary, page v.)

Chapter 1 appears to be a systematically incorrect interpretation of USDA Forest Service policy. The document does not accurately quote or describe Forest Service policy with respect to biological diversity, land or resource management.

These inaccurate narratives create a problem. If the Forest Service knowingly accepts this document into the administrative record or publishes this document in its present form, we will be claiming that these ARE accurate statements of USDA Forest Service policy.

Promotional Narratives

This document contains assertions and statements of a promotional nature, rather than of a factual, scientific or technical. The presence of these statements undercuts the credibility of this document as a scientific or technical document.

Two examples of promotional statements are the following. The first is found in the first Chapter on page 1-14 as the first paragraph under the section Biological Diversity, Conservation Biology And The Scientific Community.

> Holmes Rolston III (1986), a noted environmental philosopher at Colorado State University, points out that while humans have the powerful ability to change the natural order, they are also equipped with a conscience, not given to non-human creatures. With this conscience, humans must wisely direct and balance resource budgets. These budgets include the business resource as well as the natural resource. (Rolston,1986 pp. 164-175).

No explanation is offered for making this statement or for its inclusion in this document or in this section. The only apparent purpose of this statement is to urge the reader to wisely balance resource budgets. It's doubtful this kind of a statement belongs in a technical assessment of biological diversity for a specific National Forest.

A second instance is found on page 2-7.

> A major goal for ecosystem management is to maintain viable populations of species in the landscape in a way that perpetuates the structure, processes and functions of ecosystems at all scales. Thus, management decisions must be evaluated in the context of their direct, indirect and cumulative effects on local populations of species as well as effects at larger scales (watersheds and regional scales which are part of the landscape scale concept). The impacts of these effects over time on biological diversity deserves careful consideration.

It is as if the author is writing general statements (must be evaluated by whom and for what purpose?) to Forest Service decision makers. There is nothing particularly wrong with these paragraphs as promotional statements, but their inclusion in a document which purports to be a technical and scientific analysis is highly questionable. Or, more importantly, inclusion of these kinds of statements throughout the document tells the reader that this is NOT a technical or scientific work. It reduces the value of the document as an assessment of biological diversity for the Medicine Bow National Forest.

Risks

The Forest Service, particularly the Regional Forester for the Rocky Mountain Region, will incur three important types of risk if this document is accepted as a technical report, placed into the administrative record, or published.

The first risk is that of almost certainly incurring a significant legal liability. The document contains inaccurate descriptions of and assertions about USDA Forest Service law, regulations and policy.

If we publish this document or even accept it as a draft Forest Service technical report, we will be liable for the erroneous statements and public misunderstanding they create. We could reasonably expect to see these statements being cited to us in other public documents, appeals and litigation. We would then have the burden of disavowing them.

The second risk is that of knowingly creating public misunderstanding of (1) federal laws, regulations and USDA Forest Service policy, (2) the status of biological diversity on the Medicine Bow National Forest, and (3) biological science. Recall the point made earlier about the number of opinions and unique assertions made as if they are scientific statements, and many readers probably will regard all these assertions as fact because they lack a good knowledge of biology and because the document is dressed in a considerable amount of data and bibliographical references. This is a very real danger, given the nature of this document.

The third risk is that the Forest Service could suffer considerable loss of credibility among knowledgeable physical and biological scientists if it accepts or publishes this document. This would impair our ability to work with scientists and professional technical people and institutions in the future.

Recommendations

We recommend that you do not accept this document as a technical report, even in draft form. We believe it should not be placed in the administrative record, and that it should not be published.

The document contains much data which can be salvaged and used in an assessment of biological diversity. The general organization of the technical portions of the document is reasonable, and could be followed again, although we see no need for the Preface or Chapter 1.

A new Biological Diversity Report patterned after the one completed for the Routt Forest Plan revision should be prepared. Our physical and biological staff specialists would be willing to work with your staff in construction of a new document. We wish to recognize the tremendous amount of work that went into developing the document and am confident that portions of it will be helpful in preparing a new Biological Diversity Assessment.

DEANN ZWIGHT	DAVID ANDERSON	ELEANOR TOWNS
Acting Director	Director	Director
Planning and Budget	Renewable Resources	Physical Resources

LM:tj

Enclosure

United States Department of Agriculture | Forest Service | Rocky Mountain Region | P.O. Box 25127
Lakewood, CO 80225-0127
Delivery: 740 Simms St.
Golden, CO 80401

File Code: 1920
Date: November 22, 1995

Mr Tom Troxell
Intermountain Forest Industries
2040 West Main Street Suite 315
Rapid City SD 57702

Dear Mr. Troxell:

We received your June 22, 1995 letter regarding the Devil Creek Landscape Analysis undertaken by the San Juan National Forest. Thank you for bringing to my attention your concerns about the use of landscape analysis during forest plan implementation. We understand you have spoken with the forest and they have agreed to rework this assessment. In your letter you raised three important questions about the nature of landscape analyses. These were:

1. When is landscape analysis appropriate in the implementation of forest plans?

2. What are the appropriate objectives of landscape analysis?

3. How should landscape analyses tier to forest plan goals, outputs, and management area direction?

To combine your questions 1 and 2, landscape assessments, while not required, develop the context in which projects are planned and implemented. They are used to provide information on, and enhance understanding of the physical, biological, social and economic aspects and interactions of an ecosystem. A landscape assessment will characterize current conditions and trends. The overall goal is to collect and analyze comprehensive interagency (where appropriate), ecological, social and economic data to facilitate an ecosystem-based approach to management of the natural resources on National Forest system lands within the assessment area. Specifically, we use landscape assessments to:

* Address certain issues from a larger context, which is more cost effective than several projects addressing the same issue.

* Help comply with the many applicable environmental laws such as NFMA, Clean Water Act, Endangered Species Act, and the National Environmental Policy Act.

* Help determine cumulative effects at the project level;

* Provide improved resource integration (i.e. we can look at several potential projects on the same acres at the same time);

* Disaggregate potential implementation projects; from the programmatic level to the smaller geographic area level.

* Help identify research needs and priorities;

* Better look at broader resource topics such as wide-ranging wildlife species or whole watershed conditions;

* Compile data for monitoring and evaluation and;

* Determine historic and current resource conditions, capabilities and trends.

To respond to your third question, the landscape assessments (as stated) should basically provide inventory and trend information. They are useful to help schedule projects and provide information that can feed into project-level NEPA analyses. The forest plan is used to help frame the assessment and assessments can address specific indicators or ways the forest plan goals, desired conditions and objectives could be met. Assessments should not define or limit alternatives of strategies in plans and assessments do not make decisions. The responsible official makes the decision in a NEPA document. Assessments should also not include value interpretations. However, information gathered in landscape assessments or a combination of assessments could trigger forest plan amendments.

Our Washington Office, along with the Rocky Mountain Region and other Forest Service regions, are currently working on a national framework for assessments of all scales, therefore our response to these questions could be modified somewhat in the future.

Please contact us if you would like to express additional views of landscape assessment. We will also be happy to pass your views onto the Washington Office staff. Finally, to answer a question you didn't ask, public participation has been, and will continue to be an important part of any assessment. While not a formal NEPA process (or an informal one for that matter!) we welcome both public assistance and comments on our process.

Sincerely,

/s/ELIZABETH ESTILL

ELIZABETH ESTILL
Regional Forester

cc: Gary R. Jones
Intermountain Forest Industry Association
10 Town Plaza, Suite 275
Durango, CO 81301

R2 Forest Supervisors

TC:DZ:mg

August 28, 1995

Mr. Jerry Schmidt
Medicine Bow National Forest
2468 Jackson Street
Laramie, Wyoming 82070

Dear Mr. Schmidt:

The members of the committee have completed their reviews of the Biodiversity Report (BR) for the Medicine Bow National Forest (MBNF). D. Knight and J. Schmid reviewed most of the chapters in the report. R. Knight reviewed chapters 8 and 9, and appendices 9, 10, and 17 of the report. R. Laven reviewed chapters 6 and 9. No one on the review committee apparently reviewed chapter 7. The MBNF should have an aquatic biologist review that chapter.

The committee understood their primary responsibility was to review the report with respect to accuracy of statements, completeness of the information, and clarity of the presentation. The committee recognized that the document represents one approach for presenting the information but did not specifically evaluate whether this approach was the "best" for MBNF management, concerned citizens, industries, and environmental groups, or a combination of federal, state, and private parties. For example, another approach could have used the information in the tables, figure, and appendicies to develop biodiversity information for each MBNF biodiversity unit. Such an approach may be more helpful to future MBNF management.

Each member of the committee submitted their comments to you via J. Schmid who prepared a synthesis of their reviews. The synthesis (this letter) was then sent on August 7, 1995 to D. Knight, R. Knight, and R. Laven for their review and concurrence. The letter summarizes the committee's general impressions of, concerns about, and comments on the BR. The individual comments of each reviewer are attached to this letter for your perusal. They should be reviewed by the authors and MBNF staff because they contain more specific comments that may not be addressed in this summary letter. Further, the review draft of each committee member should also be examined because each contains specific comments on the page margins that the reviewer may not have noted in his letter to you.

The committee was impressed by the BR and the efforts of the authors, von Ahlefeldt and Speas. The report was obviously a major undertaking and represents a substantial effort in the compilation of information and subsequent composition of text. It presents current information on MBNF biodiversity as well as noting the paucity of information on this subject.

The BR is excessively long because it contains published and unpublished biodiversity information, the history of the biodiversity movement, and general discussions of ecology and ecosystem management. The MBNF must decide whether it will publish the report as is or opt for a shorter, more streamlined version which would contain essentially biodiversity information. As D. Knight points out, the BR should not be a textbook on biodiversity, ecology, and ecosystem management. Most readers will examine the BR for MBNF biodiversity information rather than a discussion of concepts. Therefore, the committee recommends the report be streamlined to a more concise presentation of the technical information.

To accomplish a more concise BR, the following changes and modifications are recommended:

1. Strong editing is mandatory for all the text. Sentences should be made more concise and direct whenever possible. Be specific, avoid vague and over-generalized statements, and jargon. Do not use sentences that merely refer the reader to a table or figure without providing some data or information within the sentence. Be sure all terms are defined or differentiated from other terms with which they may be confused. Indicate MBNF will be used for Medicine Bow National Forest after the first time the Forest name is stated and then use MBNF thereafter. The MBNF should

check with the RM Station regarding possible editing by the Station's editorial section or contract with R.H. Hamre (former editor with RM) to edit the report.

2. Standardize the format so it is consistent throughout the text. Add an index so that specific information can be located.

3. Title sections or subsections appropriately. Some subsections are titled "Biodiversity and some subject" but really contain little biodiversity information. Similarly, some subsections contain information not defined by the title.

4. Consider deleting chapters 1 and 2, and possibly chapter 3. Chapters 1 and 2 do not present strictly technical information.

5. Avoid repetition. Although not specifically documented in letters to you, some reviewers had the general feeling that the same information was presented in different sections within the same chapter or in different chapters. The reviewers recognized that most readers will not read the entire text so the presentation of the same information in more than one section helps ensure that it will be found. However, this lengthens the report and should be eliminated whenever possible. Further, similar or like sections could be combined with a broader title to reduce text.

6. Integrate tables and figures into the text. The tables placed at the end of the chapter were cumbersome and inconvienient to use for some reviewers, especially in those chapters with abundant tables. Use the legends in the colored figures to indicate what each color represents rather than stating it in the text. One reviewer thought the tables and figures should constitute the text and the current text should be rewritten to interpret the data in the tables and figures.

7. For the photo chapter, consider printing the caption on the back side of the previous page so it is across from the photo. This will eliminate a number of photo caption pages. If this is impossible from a printing standpoint, consider printing the captions on labels and then attaching to the backsides of previous pages.

Chapter 9 was the only chapter read by all committe members and their opinions varied. One reviewer thought the chapter was a marvelous attempt to integrate biodiversity and wildlands. Another liked the concept in this chapter but thought the some aspects were vague and some sections didn't really convey biodiversity information. A third reviewer thought the approach would be more useful to land managers than for his own work. Because this chapter mainly represents a method for connecting specific land designations and conveys minimal biodiversity information, the MBNF should consider separating it from the report and publishing it as a separate document.

In general, the reviewers did not recommend major additions of published information except where known data was available but apparently overlooked. R. Knight recommended expanding the sections in chapters 8 and 9 that deal with the effects of outdoor recreation on wildlife and biodiversity. Therefore, he suggested adding several references.

The reviewers realize that their recommendations will require a major revision of the BR. By making these recommendations, it was not their intent to kill the BR or to overburden the authors with innumerable changes so that the document would never be published. Rather, a document of this nature must be concise, accurate, and easy to read if it is to stand as a model for other National Forests and be used as a credible reference. The committee hopes their comments are taken in this spirit. Should there be questions, don't hesitate to contact us.

Dennis Knight Dennis H. Knight

Richard Knight

Richard Laven Richard D. Laven

John Schmid John M. Schmid

May 9, 1996

Mr. Jerry Schmidt
Forest Supervisor
Medicine Bow-Routt National Forest
2468 Jackson Street
Laramie, WY 82070

Dear Jerry:

I have received your letter of April 26 with the review of the May, 1995 MBNF Biological Diversity Technical Report by the Regional Office attached. Your decision, which appears to totally reject this report, and the recommendation by the Regional Office Directors not to even recognize its existence in the Administrative record, was a complete surprise to me.

There is misunderstanding as to the purpose and type of this document by the RO. It is a specialist report, prepared as a review and compilation of information on MBNF biological diversity including the human dimensions of history, and recent public discussion of Forest Service policies and precedents. It contains limited evaluations and analyses (more need to be done later after Plan Revision resumes), and identifications of concerns and considerations for planning and management. The identifications of concerns and considerations for planning and management are not directions for management. The report is NOT a formal Biological Diversity Assessment for planning purposes *sensu strictu* because it was written mostly during the time period when the Medicine Bow National Forest Planning Team was disbanded and redirected to work on the Routt NF DEIS (April 1994 to March, 1996). Therefore there was no interdisciplinary context for a biological diversity assessment to be prepared within since no other assessments were being done concurrently. It is expected that other documents satisfying NEPA or Regional Office requirements, and carrying the endorsement of the Forest Supervisor, will be prepared later.

The report is NOT a General Technical Report prepared for the review process for NFS Research. It was never intended to be "published" in its present form any more than other specialist reports are "published". Our intent was to print approximately 25 copies as a limited edition specialist report for use by Districts, SO Staff, the Plan Revision Team, our partners and our publics. There are some sections of the report which might be considered for future formal publication after proper review for formal publication - for example the bibliography of scientific studies and the climate or fire history appendices which have usefulness beyond the MBNF.

All of the information in this document is in the public domain whether it is from published literature, Master's and PhD work, contracts, administrative studies, reports from other agencies or the RIS data base. It should not be censored or suppressed. It is properly documented and up-to-date. If new information is acquired or if honest mistakes are found, they should simply be recognized as such and additions or corrections made. The report received careful preparation, the chapters and appendices were reviewed by both MBNF staff and outside reviewers (in total) before the May 1995 version was submitted and it has since undergone extensive reviews by the Scientific Peer Review Committee, the Administrative Review Committee and many District staff. I submit that there are very few data errors in this report and the May 1996 revision has addressed other detail concerns which were identified during the scientific and administrative reviews.

At the October 12, 1995 meeting I was instructed to "dot the i's and cross the t's" and make the changes specified in the DRAFT letter to the Regional Forester which you presented as your plan for further action on the biodiversity report at that meeting. You allowed me two weeks to do this. You wanted to retitle the report to **Summary of Existing Research on the Biological and Physical Conditions of the Medicine Bow National Forest** (confirmed in letter from you October 24, 1995). I was told at the meeting that the report would be accepted with the required changes made. I was not in agreement with the title change, I did not and still do not understand, why a specialist report was sent for Regional Review, especially if it is merely a compilation of research as your title implies. I also did not concur with making only minimum changes required (all of which were from Administrative Review only) because that neglected many fine recommendations to improve the report made by both the Scientific Peer Review Committee and the Administrative Review Committee. These recommendations included not only minor corrections, editorial changes and rewording, but the placement of tables within text, addition of a glossary and index, and removal of redundant information.

I have revised the report, corrected typographical errors and have made the minimum required changes specified in the DRAFT letter to the RF. In addition, the May 1996 revision includes the following changes: 1) use of scalable fonts for the text chapters to make the text easier to read, 2) integration of tables into the text (figures are still grouped at the end of each chapter), 3) a glossary and index has been added, 4) the executive summary has been removed and replaced by a general summary and 5) a chapter on concerns and considerations has been added as Chapter 10. One figure (Figure 6.30) was added to chapter 6 to illustrate the relationship between stand age and acreage, but no other changes except corrections or editing of captions were made to other figures or tables. The

majority of the text remains the same except for minor corrections. Chapters 1 and 2 have been reorganized and shortened to eliminate redundancies.

Most of this was completed during the last few weeks of November and I had informed Lee Kramer, Steve Christiansen, Carol Tolbert and Marla Wertz that I expected to assemble the revised document in early December. Because of the furlough and my being on leave due to family illness, the document assembly was not completed until I returned to Laramie at the beginning of May.

The Regional Office review was based on the May, 1995 version, review of which was requested before I had opportunity to make the changes recommended by the Scientific Peer Review and Administrative Review Committees. Most of the specific concerns identified by the RO review team had already been noted by one or both of the other reviews and had been corrected, changed or deleted from the report by the end of November during revision. I had inquired of both Steve Christiansen and Lee Kramer as to what effect Regional comments would have on the work completed in November and neither of them was sure of the answer.

This document was initiated at the behest of former supervisor Gary Heath who liked the work done by Clay Speas, Malcom Edwards, Tim Byer and myself on the biological diversity of Thunder Basin National Grassland. Chapters 1 and 2 in that document are similar in both intent and content to the first two Chapters of the MBNF report which were critically reviewed by the RO letter. In fact, Tables 1.1, 1.2 and 2.1 are identical in the two reports, and many of the references to, and discussion of, law, policy, precedent, ethics and ecosystem scale are common to both reports. The appropriateness of including this information in the TBNG Biological Diversity Technical Report was debated in 1992 by the Planning Director (Doug Larson), the Resource Staff Officer (Ron Olsen), the EIS preparer (Terry Dilts) and Regional Office staff. This resulted in a meeting in December, 1992 at the RO among these individuals, Clay Speas, myself and members of the RO staff including legal counsel. It was decided then that the discussion of these topics was acceptable information. The TBNG report has been out for four years, it has been well-received by District personnel and other agencies (especially the BLM), and has provided useful information for the current IRI survey. There have been no repercussions or legal liabilities regarding information in chapters 1 and 2 of the TBNG report. I do not agree that the same and similar information is inaccurate in the MBNF report and would put the Forest Service at risk.

I do not agree with the evaluation by the Regional Office that the document does not make use of scale. The treatment of scale is perhaps not in the language or

format desired by the Regional Office, but I have seen no guidelines on this other than to use "coarse filter, fine filter and RNV" as minimum requirements. Chapters 3, 6, 7 and 9 are directed at the coarse filter scale (whole landscapes and communities), Chapter 8 addresses species and genes at the fine filter scale, and the appendices on plant and animal species richness address also the fine filter scale.

Contrary to the claim the in RO letter than common species are discussed (but should not be), Chapter 8 does focus on rare species. All species included in the Chapter 8 summaries (which address national status, management considerations, habitat, and occurrence on the MBNF) are Federally Threatened or Endangered, R-2 Sensitive, (former) C2 species or some combination of these. Emphasis is on rare species in this report, but insofar as possible, all species are recognized as contributors to biodiversity. If the Regional definition of biological diversity defines biological diversity as the "full variety of life in an area" then why does the RO letter say that "Biological Diversity Assessments should focus on rare species, not ones that are common"? (page 3 of RO letter)

The report was critized for lack of attention to scale. In fact, this report addresses scale in great detail, but mostly from the scale of the entire Forest downward to watersheds and stream reaches, rather than upward to Section and Province. Draft Subsection descriptions are provided to link Subsection information to MBNF landscapes. Section descriptions are published elsewhere. A grid of watersheds and groups of watersheds is used on nearly all GIS-generated maps so that areas can be compared among maps displaying different data attributes. Data is summarized in tables by watershed, by watershed goups, within mountain ranges and forest-wide. This methodology does recognize scale at levels which seem intuitively more useful to managers than larger scale data and maps such as those for Ecological Provinces or Sections. The larger scale information is useful of course, but it was not available (and I believe still not complete) from the CSU GIS mapping efforts. It has a different utility to planning and projects than information specific the the MBNF which can later be upwardly aggregated into the context of Ecological Section or Province. Data at smaller scales can be aggregated upwards, but the reverse is not true. Similarly, the plant and animal lists in the appendices, stratified by mountain range to show diversity within the MBNF (as specific as the data would allow) is of use to managers and planners in a different way than, for example, the Rare species tables for Ecological Sections M331H and M331I in the 1996 Routt DEIS page D-19 which do not specify which species actually occur on the Routt NF or how species diversity varies among different landscape areas.

The RO report criticizes the MBNF report for lack of information on species and

habitat, yet there is a table on Neotropical migratory birds and their habitat relationships, discussion of this in the text section on Neotropical migrants, and for each species discussed in Chapter 8 there is a discussion of habitat. The information in these summaries comes from District Biologist reports and was supplemented by reviews from Forest Service and University Researchers for specific species such as goshawks and other raptors, amphibians and American marten. The summaries are documented, they are current and they pertain specifically to the MBNF. If NEPA or Forest Plan Revision documents require larger scale tables or discussion, that is fine but that does not denigrate the value of the MBNF-specific information in the MBNF report.

The RO report claims that variablity of climate was not recognized. In fact the first sentence on page 3-14 under "Climate Patterns" states "The Medicine Bow-Routt National Forest includes the most climatically diverse forested areas in Region 2 with regard to precipitation". On page 3-15 diversity of four major climate patterns based on Principal Components Analysis of climate data are presented and the climate appendix contains a full array of climatograms. I submit that this is a very detailed and well-documented discussion of climate that is useful in many ways to both planning and projects.

The report is extremely well-documented, not "dressed in a considerable amount of data and bibliographic references" (RO letter page 6) which may mislead readers. The Forest Service should not be criticized for recognizing available and valid information. The Forest Service, as an agency has received criticism in the past for not using available information and many NFS reports have very few citations to published information. There is no intent in this document to mislead anyone, but rather to make information sources available. It is my job, as a scientist in NFS, to provide this kind of information.

There are many other items in the RO letter which I would be happy to respond to because I do not think the evaulations are accurate.

As Forest Ecologist, my job description includes:

" -development of ecosystem classifications which will serve as a framework for the management of ecosystems and revision of the Forest Plan

-training other Forest personnel in the principles and application of ecology to ecosystem management

-recommends or develops management practices that can be successfully implemented by the professional land manager

-formulates and recommends policies, programs, and plans for the conservation, utilization and development of the various ecosystems on the National Forest and National Grasslands

-disseminates ...up-to-date technical information relating to ecosystems analysis, function and management

-receives only general guidance and direction, has considerable latitude for independent action and initiative

-the work product affects a wide range of Forest Service activities such as land management planning, fish and wildlife management, range management, timber management, soils and mineral areas management, hydrological and silvicultural prescriptions, recreation management, and the research natural areas and threatened and endangered species programs."

I believe I have done my job preparing this report, and Clay Speas and I have provided a wealth of organized information for use by planners, districts, other agencies and the public based on our expertise and on-the-ground familiarity with ecosystems and species of the MBNF.

This document was prepared with the assistance of many individuals in the scientific community at the University of Wyoming as well as from other agencies such as WY Game and Fish and The Nature Conservancy, and Forest Service Research. Results of three recent Master's Theses projects are directly involved with this report (landscape metrics on Tie Camp, mycorrhizal measurements from clear cuts, soil fertility measurements from clear cuts). A peer-reviewed paper on landscape metrics has been recently published in the international scientific journal **Biological Conservation** (Issue 75; 1996), and a paper on the mycorrhizal studies is in preparation for the Canadian Journal of Botany by a Master's student at the U WY. The "factor analysis" (page 3 paragraph 4 of the RO letter) used as a basis for evaluating RNV, was the subject of a contract which was completed in December 1994 and accepted by the MBNF. Dr. William Baker of the University of Wyoming Geography Department is an extensively published and well-respected landscape ecologist. The list of production credits in the report recognizes the contributions of many others. Much of this report was reviewed by partners at the University and from other agencies and these people are waiting for its completion.

Thus, contrary to the contention in the RO letter that this report has questionalble information and would cause a "considerable loss of credibility among

knowledgeable physical and biological scientists if it accepts or publishes this document" (RO letter page 6), I think that quite the contrary is the case. Some serious questions about why release of this report has been delayed for a year in review, and then deemed unacceptable, will be raised from many quarters if it is rejected, not entered into the Administrative Record, and the work of the authors is not recognized.

Jerry, I can understand if you do not feel you can endorse this report, but that is not the same thing as accepting it as part of the information available to the Forest. While you may not consider this document as the formal, final Biological Diversity Report for the Forest Plan Revision, I hope the May 1996 revision can be accepted for the uses for which it was intended. I hope that you will find the May 1996 revision improved and more user-friendly. I have worked hard to incorporate the many fine suggestions for improvement of the format and content of the report and it is my hope that this document will be a solid foundation of information and ideas to serve planning, projects and dialogue with partners and publics. I will give Dee Hines the electronic copies as you have requested for preparation of the Forest Plan Revision Biodiversity Assessment and I would welcome the opportunity to brief the FLT and District staff on the organization of the May 1996 report so they will find it easier to use.

Respectfully submitted,

Judy von Ahlefeldt

Dr. Judy von Ahlefeldt
Forest Ecologist